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# WILEY'S HEALTH SERIES

## NUTRITION HYGIENE PHYSIOLOGY

BOOK THREE

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WILEY'S HEALTH SERIES

# BOOK THREE

# WILEY'S HEALTH SERIES

NUTRITION—HYGIENE—PHYSIOLOGY

## BOOK THREE

*By*

HARVEY W. WILEY, M.D.

*Formerly chief chemist of the United States Department of Agriculture. Editor of "Good Housekeeping's" Bureau of Foods, Sanitation, and Health. Author of "Foods and Their Adulterations," "Principles and Practice of Agricultural Analysis," "The Lure of the Land," "Not by Bread Alone"*

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# A FOREWORD

I believe it was George Ade who said, "If you want to uplift, get beneath." This sentiment is peculiarly applicable to the study of physiology in the schools. Such terms as "anatomy," "physiology," and "hygiene" terrify the children, and to a certain extent make them antagonistic to the study. I have long thought that the proper way to get children interested in this matter was to make the subject a living one. I have sought to get entirely under it and to present it in a vital way. My experience is that children are easily interested in matters that pertain to their daily life if we go at it in the proper spirit. Instead, therefore, of the dry details of physiology, I have tried to lead the child into the midst of the phenomena of the life he is living and to tell him in simple language of the character of the environment in which he lives.

I begin by taking him outdoors and allowing the wind to blow in his face. I lead him to the fireplace and let him warm his fingers. I take him to the spring and show him the water that he drinks. I go with him into the fields to watch the growing food. I visit with him the mills where this food is being prepared for consumption. I tell him of those things which are vitally related to his daily life and which are the groundwork of his health and growth. I have endeavored to put the material into the form in which the child naturally absorbs it. The child is an interrogation point. He asks questions. I have taken the questions which have been suggested to me by talking with children, and have tried to answer

the questions they have put to me. While this method of preparing a physiology is novel and radical, to my mind it seems natural and workable. With the help of the teacher the child will at once become interested in the phenomena of existence. The study will not be a burden, but a revelation and a pleasure.

While it has seemed advisable in some places to use words which children do not understand, their meanings have been given so that they may know what they are reading about. The dry details of the usual form of study on this subject have been entirely eliminated. The child who reads this book properly under competent instructors will have a new view of life, a better understanding of his environment, and a clearer conception of what is good for his health. He will be asking himself continually, when new duties and new pleasures present themselves, or new foods come to his attention, this question: Is it good for me?

HARVEY W. WILEY

*Washington, D.C.*
*April, 1916*

HARVEY W. WILEY, M. D.

# WILEY'S HEALTH SERIES

## BOOK THREE

## I. How Do We Grow?

### A STUDY OF FOODS

**What is the purpose of food?** All living things require food. This is true of plants as well as of animals. The young plant gets its first nourishment from a supply of food stored in the seed. Some seeds, like nuts, are very large, and contain a great deal of nourishment. Other seeds are very small and so can contain only a small quantity of nourishment. But all seeds always contain food enough for the young plant during the first period of growth.

*Sprouting cereals in water*

There is enough food in the seeds of all cereals to sustain the young plants growing from them for several days. But then, if no additional supply of nourishment is provided, the young plants die. You may prove this by a simple experiment. Fill two basins with distilled water. Distilled water contains practically no food that will promote plant growth. Over the surface of the water place cloths that have been

thoroughly washed in distilled water to remove any material that might nourish the plant. The threads in the cloth must be far enough apart to leave space for young rootlets to grow down into the water. On top of the cloths place a number of grains of wheat, and set the two basins in a dark place where the temperature is not below fifty-five or sixty degrees. When the wheat has sprouted and is fully developed, bring the basins out into the light. The sprouts will soon turn green, and the roots will reach down through the cloth into the water. Gradually the grains of wheat will disappear, leaving only the hulls. Then the growth of the plant will cease.

Now add a little plant food consisting of phosphate of soda, powdered gypsum, and nitrate of potash to the water in one of the basins. Then watch what takes place.

In the basin where you added the plant food the plants will grow vigorously as long as the plant food lasts. The young plants in the other basin, where no nourishment was added, will die. In the first case you fed the plant; in the second you starved it. Corn or any other cereal may be used for this experiment.

When an animal is born it can live two or three days without any nourishment. But very soon thereafter, if no food is given it,

the young animal will die. Given the proper nourishment, it will not only live, but it will continue to grow. Thus we see that in order to live and to grow both animals and plants must be supplied with food.

**How may the foods of animals be classified?** In classifying foods suitable for animals, we find five principal divisions: *Mineral* foods (lime, phosphate, soda, potash), *nitrogenous* foods (protein), *carbohydrates* (sugar and starch), *oils* and *fats*, and *condiments* (seasonings). All the food we eat may be classified under these five heads.

Foods may also be classified according to other standards. Most foods may be classified broadly as animal or vegetable products. In a more detailed classification of foods according to their natural form we have meats, poultry, fish, game, cereals, milk, fruits, vegetables, and nuts. With regard to their preparation foods may be classified broadly as cooked or raw foods. With regard to the various forms in which they are prepared for use they may be classified as flour, bread, butter, cheese, cream, cured meats, smoked meats, dried fruits, canned fruits, canned vegetables, breakfast cereals, and such foods as jams, jellies, and preserves.

In our discussion of foods we shall begin with the minerals.

## A STUDY OF MINERAL FOODS

**What are the chief minerals contained in foods?** Nearly all the mineral substances that are present in the soil are also present in vegetable products. Animals must have some of these mineral foods at all times in order to live; others are valuable at certain times and under certain conditions. The mineral substances that animals must have are phosphoric acid, lime, iron, soda, potash, iodine, and magnesia.

**What foods contain the most iron?** Some kinds of food contain a great deal more iron than others. Of the vegetables, spinach is believed to contain the largest amount. There is also much iron in the cereals, and traces of it are to be found in most of the foods we eat.

**Is there any danger in taking too much mineral substance into the body?** The rule that applies to all other foods when taken in excess also applies to mineral substances. If more minerals are taken into the body than are required for its proper nourishment and growth, the body must get rid of the excess. This is done by the organs that remove wastes from the blood and send them out of the body, especially the kidneys. To get rid of an excess of minerals too great a burden is placed on these organs, and this, if continued, may prove harmful.

As a general rule, when we eat one hundred

pounds of food, from one and a half to two pounds of it should consist of mineral substances. More than this would probably be harmful, and any considerable quantity less would certainly be so. Therefore, in the preparation of food for eating, the natural mineral content should be reduced as little as possible. It is really better to eat the skins and outer coverings of such foods as cereals and potatoes and apples, than it is to discard them, for in the bran of cereals and in the skins of potatoes, apples, and other fruits and vegetables is found most of the mineral content of those food products.

## A STUDY OF FOODS CONTAINING NITROGENOUS SUBSTANCES

**What foods are the chief sources of protein?** Protein, the food element containing nitrogen, is present in nearly all our vegetable and animal foods. Among the foods containing the largest proportion of protein is lean meat. About sixty per cent of the content of ordinary fresh lean meat is water, the remaining forty per cent being largely protein and fat. This is true of both red and white meats.

Milk is another animal food in which there is much protein. About three and a half per cent consists of protein. But since there is only

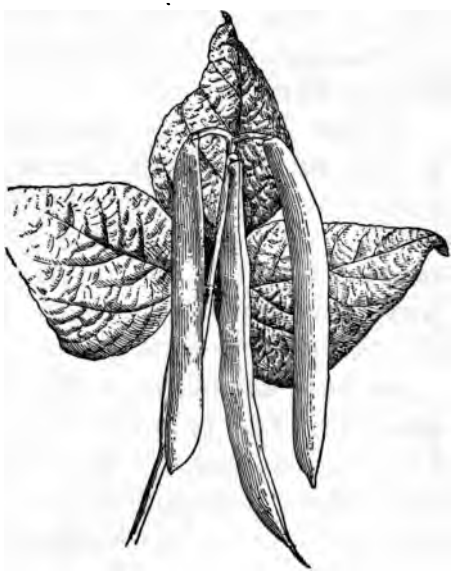
thirteen per cent of dry food in milk, the rest being water, it is evident that a little more than one fourth of the total amount of dry food in milk is protein. In cheese the proportion of protein is considerably greater than it is in milk. There is also a large quantity of fat in cheese.

*Pea pods*

Another food containing a large proportion of protein is the egg. The white of an egg is more than seventy per cent water. The remainder, or thirty per cent, consists largely of protein. The yolk of an egg contains less water than the white of the egg, and also much less protein. A large part of the yolk of the egg consists of fat.

Among the vegetable foods, peas and beans are rich in protein. Among the cereals, oats contain the highest proportion of protein and rice the lowest. Not more than eight per cent of the content of rice is protein. From ten to fifteen per cent of the content of wheat is protein, while Indian corn contains less protein than wheat, and barley and rye almost as much.

While peas and beans contain much protein, the amount in other vegetables is comparatively small. The percentage of protein in the potato is small. Fruits and succulent vegetables also contain a comparatively small amount of protein. Nuts, and oily seeds such as cottonseed and flaxseed, contain much protein. From this we learn that if we should limit our diet to a single food we might select one with a very high content of protein, such as oats, peas, or beans, or we might select one with a very low content, such as rice, potatoes, or fruits. But if we know the proportion of protein in the various kinds of food we can select them so as to get the exact amount of protein needed for our proper nourishment and growth.



*Bean pods*

**How much protein should we eat a day?** This is a question that has been the subject of much

discussion. Some experts claim that we should eat a large quantity of protein; others claim that a small amount is better. The proper amount is probably between these two estimates, or a medium quantity.

A man who weighs about one hundred fifty pounds and is engaged in active work needs from three and two tenths to four and three tenths ounces of protein a day. But we must remember that other food elements are as necessary to nutrition as protein. The proper quantity of those elements will be discussed later.

**Are there differences in the nutritive qualities of proteins?** The proteins in different kinds of food, both animal and vegetable, differ in nutritive value. Comparing the body to a house built of brick or stone the protein may aptly be regarded as the bricks or stones out of which the structure is built. Protein is the essential material composing the muscular tissues of the body. It is also a very important element of the nerves and the brain, and is one of the chief substances in the blood. Protein is almost the sole material in the hair, the nails, and the skin. It is a very important element in the bones of the body. It is found, although in small quantities, even in the fats of the body. Thus the statement that protein is the principal building material in the bodily structure is fully justified.

You have noticed that different clays make different kinds of bricks. Some are red, some gray, some almost white, and some yellow. Some bricks are very hard, some have been

*Protein "bricks" used in building the body*

melted, or vitrified as it is called, until they are glassy, and some are so resistant to heat that they cannot be vitrified, and for that reason are used to line furnaces. And yet all bricks are made out of clay. In the same way we may

find differences in the protein "bricks" out of which the bodily structure is built.

Among the best protein bricks with which to build the human body are those made from the casein of milk and the gluten of wheat. The protein of Indian corn, if no other "clay" is mixed with it, makes the poorest bricks.

The proteins themselves are not bricks or building stones of the body any more than beds of clay or unquarried rocks are bricks or building stones of a house. Just as bricks are molded and baked in the kiln, so the proteins are treated in the digestive apparatus and made into "building stones" or "bricks" suitable for the bodily structure.

When proteins are used in the body, whether they are built into the tissues or are burned directly in the *blood stream*, a waste material (urea) forms which is more or less injurious or poisonous. For this reason not more of this building material than is really necessary for the growth and nutrition of the body should be used.

The foods containing protein in large proportions and carbohydrates in small proportions or none at all are generally the most expensive. A nation that produces plenty of food, or has plenty of money with which to buy food, is apt to choose expensive foods, such as meats, eggs,

and milk. Therefore the people of that nation are apt to eat too much protein and not enough carbohydrates. On the other hand, if a nation produces little food, and has little money with which to buy food, it must content itself with foods that are poor in protein, such as rice, Indian corn, and potatoes. The people of such a nation no doubt do not get enough building material. But the nation whose resources permit it to take the middle course between these two extremes will have the advantage, since the people will get enough protein for building purposes and at the same time avoid an excess of waste material.

Growing children need more protein than grown people. They must not only replace old building material, but they must also provide building material for new growth. They must have material to repair the old building and at the same time bricks for the additions. For this reason the diet of children should contain a larger amount of protein in proportion to other elements than that in the diet of grown people. Milk, the natural food of the infant, contains a small amount of protein in proportion to other elements, because nature did not intend infants to grow very rapidly. Mother's milk contains a smaller proportion of protein than does the milk of the cow, since nature intended

that the calf should grow more rapidly than the human infant.

When children reach the age of six or seven years they begin to grow rapidly. Then cow's milk is better for them than the milk that was suitable when they were infants. There should be an abundance of protein in the food of a child during the period of rapid growth, which usually is between the ages of seven and seventeen years. After the seventeenth year the amount may be diminished with safety.

## A STUDY OF CARBOHYDRATES

**What is the function of the starches and sugars contained in foods?** Starches and sugars make up the greater part of human foods so far as weight and bulk are concerned. The chief function of the carbohydrates (starch and sugar) in the body is to produce heat and energy. At the same time the carbohydrates aid in the digestion of other food substances and in changing them into the form in which they are used for building tissue. They also aid, to a certain degree, in forming fat tissues in the body. Because starch and sugar produce heat and energy when consumed or burned in the body, the carbohydrates are called fuel.

Nature intended that all the different classes of food—protein, carbohydrates, fats and oils,

minerals, and condiments—should be present in the ordinary processes of digestion. Not the carbohydrates alone but every class of food exerts a profound influence on the relations of every other class in the process of digestion. Thus the nutritive value of any class of food can be studied only in the relation of that class to the nutritive value of all the other classes.

**What foods are particularly rich in starch and sugar?** When we speak of a starchy food we naturally think of the potato, which consists almost entirely of starch. It is true that the potato contains a small quantity of protein, a considerable quantity of mineral substances, and a slight trace of oil. But all these things together form only two or three per cent of the weight of the potato, while the starch, including the small amount of sugar combined with it, forms from sixteen to eighteen per cent of the weight. The remainder is water and indigestible fiber.

There are other foods containing about the same proportion of starch as the potato. Among these are arrowroot and cassava. These products grow chiefly in tropical and semi-tropical regions, while the potato grows in temperate and north-temperate regions. Closely related to the potato are the so-called sweet potato and the yam. These also contain large quantities

of starch, together with considerable quantities of sugar.

Among the cereals, rice contains by far the greatest amount of starch, about eighty per cent of the rice grain consisting of starch. Among the other cereals, Indian corn contains the largest amount of starch, and oats probably the smallest. But all the cereals contain considerable quantities of starch. The amount ranges from eighty per cent in rice to sixty-five per cent in oatmeal. Thus we see that the principal food product in cereals, so far as quantity is concerned, is starch.

There are many prepared foods in the market that are almost pure starch. Among these we find tapioca, cornstarch, cassava starch, and arrowroot. They are used extensively in preparing puddings and custards. So far as value is concerned, such foods are excellent for the production of heat and energy. They also aid other food substances in the work of promoting growth and restoring tissue, though they are themselves of little value in that work.

The starch used in this country is produced principally from corn. In Europe the principal source of starch is the potato.

As we grow up our need for carbohydrates increases. This is a natural result of the greater demands made on the system for heat and

energy, furnished so abundantly by the carbohydrates. Thus the proportion of starch and sugar in the diet of the grown person should be much greater than the proportion found in milk, which is the ideal food for the infant and the child.

**How can the carbohydrates aid in digesting and preparing other food elements for use in the body?** This is easily explained. The human body requires a varied diet, consisting of the five classes of food elements already mentioned. This is a normal or natural requirement. The different organs of the human body can do their work best only when the food elements are of the normal quality and in normal proportions. Any departure from this must necessarily be more or less injurious to the whole system.

The truth of this is evident in sickness, when it is necessary to alter the proportion of the different classes of foods in the diet in order to meet the conditions brought about by the disordered functions of the body. In some diseases it is advisable to reduce considerably the quantity of carbohydrates (sugars and starches) in the diet. If this restriction is carried to a certain degree, improvement takes place. On the other hand, if the carbohydrates are entirely taken away the effect may be, and usually is, decidedly harmful.

In building a house various materials are required — wood, lime, sand, stone, bricks, nails, iron and lead pipes, and furnaces. When the proper amount of all materials is used the result is a house of good appearance and quality, suitable to live in, and comfortable. The result would be quite different if some materials were left out altogether and others were used in excessive quantities. If bricks were used without mortar, the house would soon fall to pieces. If too much wood were used, the house might take fire from the furnace, and so with every other material used in building the house. This is an illustration of what happens when we eat too much of one kind of food and not enough of another. Our foods should be so selected as to furnish all the materials needed, and all in the correct proportion for the proper development and growth of the body.

## A STUDY OF FATS AND OILS

**How are fats and oils used in body building?** A considerable proportion of the foods we eat, both vegetable and animal, consists of fats and oils. The terms "fat" and "oil" apply to the same substance, although there is a distinct difference between the two. The term "fat" is applied to a solid fat, that is, a fat that is solid at the temperature of the human body.

The term "oil" is applied to a liquid fat, that is, a fat that is liquid at the temperature of the human body. Most vegetable fats are liquid and most animal fats are solid. Fats and oils are formed of essentially the same elements that exist in the carbohydrates.

**What is the function of oils in nutrition?** Oils aid digestion because their flavor and taste make the foods in which they are present taste good. But the chief function of oil and fat in nutrition is to furnish heat and energy. Oil or fat furnishes a greater amount of heat than any other element of food.

**Does an excess of fat in the tissues of the body shorten human life?** This question cannot be answered definitely in regard to any one of us. So many things influence the length of human life that we cannot discover with any certainty the influence of one thing alone. Studies have been made comparing the length of life of a great many persons. From these

*A boy of overweight and a boy properly proportioned*

studies it has been estimated that if a man six feet tall weighs two hundred forty pounds, that is, fifty to seventy-five pounds more than he ought to weigh, we may expect that his life will be shortened by about four years.

**What is the proper weight for grown persons of a given height?** Various authors have constructed tables to show the proper weight for grown persons of a given height. The table below gives the average weight of men and of women of all ages combined from 15 to 70 years at a given height, and also the average increase in weight for each inch in height.

| HEIGHT | MEN | INCREASE IN LBS. FOR EACH INCH IN HEIGHT | WOMEN | INCREASE IN LBS. FOR EACH INCH IN HEIGHT |
|---|---|---|---|---|
| 4 ft. 9 in. | | | 116 | 4 |
| 10 in. | | | 118 | 2 |
| 11 in. | | | 120 | 2 |
| 5 ft. 0 in. | | | 122 | 2 |
| 1 in. | 129 | | 124 | 2 |
| 2 in. | 131 | 2 | 126 | 2 |
| 3 in. | 133 | 2 | 129 | 3 |
| 4 in. | 137 | 4 | 132 | 3 |
| 5 in. | 141 | 4 | 136 | 4 |
| 6 in. | 145 | 4 | 140 | 4 |
| 7 in | 149 | 4 | 144 | 4 |
| 8 in. | 153 | 4 | 148 | 4 |
| 9 in. | 157 | 4 | 152 | 4 |
| 10 in. | 162 | 5 | 156 | 4 |
| 11 in. | 168 | 6 | 159 | 3 |
| 6 ft. 0 in. | 174 | 6 | 162 | 3 |
| 1 in. | 180 | 6 | | |
| 2 in. | 186 | 6 | | |

Adapted from Medico-Actuarial Mortality Investigation, Vol. I, 1912

## A STUDY OF THE BALANCED RATION

**What is meant by a balanced ration?** When building a house the builder always begins by making an estimate of the exact amount of every kind of material that will be needed. It would be very foolish for him to buy a great quantity of lumber and bricks and not buy any sand, mortar, and nails. So the wise builder calculates very carefully the quantity of each kind of material he must have in order to complete the building. As a result, when he begins his work he will have on hand just the right amount of all materials, even to the paints, varnishes, and trimmings. When his work is completed there will be very little building material left over.

At the same time the wise builder always tries to make certain that he has enough material. It would be better for him to have a little too much than not enough. To have too little of any one kind of material might be very costly, since the whole work would have to be delayed until the additional material could be bought. The house builder, in other words, secures his material in such quantities that he has enough of each and every kind, no matter how small or how large a quantity is necessary for the work that is to be done.

This principle holds good in supplying food

material for building up the body. We must endeavor to supply all the necessary materials, and in such quantities that there will be neither too much nor too little of any kind of material. We then have what is called a balanced ration. Yet, as in the case of the house builder, it is better to have a little too much than not enough of any single article. But such excess should be limited to the smallest possible amount, so that after the food is consumed and digestion is complete, very little waste will be left. In this way the needs of nutrition will be well and fully satisfied.

**How many kinds of materials are required for body building?** It has been estimated that from twelve to fifteen different substances are required in the process of nutrition. Some of these things are similar in character to the paints, varnishes, decorations, and trimmings used in the building of a house. To leave them out would have little effect on the strength of the building, but neither the building nor the body would be quite complete or wholly presentable without them.

If we select our common food products wisely, and in the correct proportions, we secure all the twelve to fifteen substances needed in nutrition. If we do not use wisdom and judgment in our selection, some essential substances will

probably be overlooked. The result will be a body that is weak and out of proportion.

**What essential materials are commonly omitted?** Among those commonly omitted are the mineral substances, so essential to the proper building of the body. In preparing our foods we usually throw away the portions that contain much mineral substance. The peelings of apples, potatoes, and other vegetables, the bran of wheat, oats, and corn, and the germs of cereals all are rich in oil and phosphorus. With the minerals we also reject the life-giving vitamines present in the outer coverings of these foods.

Usually the statement of a balanced ration contains no reference to the mineral constituents or the condiments. Yet to supply these substances is not only advisable but absolutely necessary. From one and one half to two per cent of the total daily ration should consist of minerals, chiefly lime and phosphoric acid, with small quantities of potash, iron, soda, iodine, and magnesia. This requirement will be fulfilled if we eat foods no part of which has been discarded or greatly altered in the process of preparation.

**Why should condiments be used?** We should next consider the necessity for condiments. The condiment used in largest quantities is salt. As in the case of other useful substances,

an excess of salt is injurious. No more salt should be used than is necessary for proper relish or seasoning purposes. Salt is used with some foods and not with others. It is used, almost universally, in bread, with vegetables and meats, and in butter and cheese. On the other hand, we do not usually put salt on fruits or in milk.

Other condiments, such as peppers, spices, and mustard, are commonly used with meats. Some are used with eggs and vegetables, especially in salads. These condiments are generally added in small quantities, otherwise the foods would be too strongly seasoned to suit the taste. Wood smoke, as you have already learned, is a condiment used in curing meats, such as ham and bacon. This condiment has a double purpose; it preserves the meat from infection by insects and bacteria and also adds a flavor that is well liked.

With the exception of salt, the condiments form a very small proportion of our food. Probably they do not exceed one twentieth or one fifteenth of one per cent of the total ration. The precaution with regard to the use of salt applies to the use of all condiments. They should all be used sparingly, just enough properly to stimulate the glands that supply the digestive fluids.

**What should be the relative proportions of the chief food ingredients?** Assuming that the mineral substances and condiments are present in the correct quantities, we must now consider the correct proportions of proteins, carbohydrates, and fats in a balanced ration. Experience as well as a careful study of the food supply of human beings under various conditions and in various countries has revealed the quantities in which these food substances should be present in order to make a balanced ration.

The standard ration of dry food for a man weighing one hundred fifty pounds is nearly one pound and a half, or 640 grams. For a ration in which there is a generous proportion of protein, this 640 grams should consist of 120 grams of protein, 440 grams of carbohydrates (sugar and starch), and 80 grams of fat or oil. This is considered the proper proportion of ingredients in a well-balanced ration.

Specialists in the study of diets have a way of determining whether a ration is properly balanced. They multiply the number of grams of fat by two and one quarter. To this product they add the number of grams of carbohydrates. Then they divide this sum by the number of grams of protein. The quotient thus secured is called the *nutritive ratio*. Applying this rule to the standard ration of dry food given on

the preceding page, we get the following results:

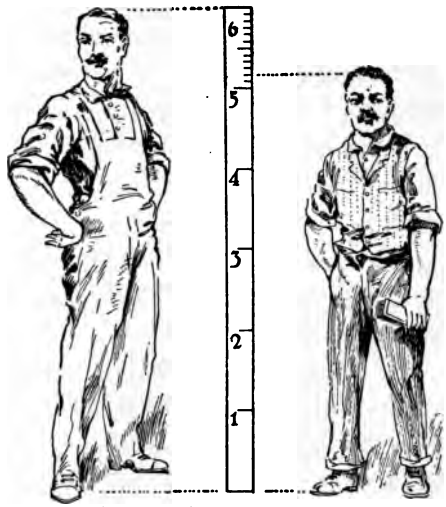
80 multiplied by 2¼ = 180
440 added to 180 = 620
620 divided by 120 = 5.2

This quotient (5.2) is the *standard nutritive ratio.* Assuming that there is the needed quantity of mineral matter and condiments in the ration, this quotient, 5.2, tells us that we have a standard ration in which the ingredients are present in the correct proportions. If we should decrease the amount of fat to 60 grams, and increase the carbohydrates to 450 grams and the protein to 130 grams, so as to make the same total, 640 grams, we would then have this problem:

60 multiplied by 2¼ = 135
450 added to 135 = 585
585 divided by 130 = 4.5

This quotient is less than the quotient (5.2) which has been taken as the standard nutritive ratio, and so we have what is called a "narrow ratio," meaning one with too much protein. On the other hand, if the quotient obtained by some other arrangement is more than 5.2, we may conclude that we have what is called a "wide ratio," or a ratio in which there is an excess of carbohydrates and fats. The wide ratio is best suited for men who work at hard physical labor. The narrow ratio is best for men engaged in less active physical labor, for those

who sit a good deal, and for those who do not wish to increase their weight. But any great variation from the standard nutritive ratio is more or less dangerous to health. Among those nations whose nutritive ratio commonly is wide, that is, if the nutritive ratio runs from 7 to 9, as in Spain, Greece, and Italy, the people are small in stature. If the ratio is narrow, as in the United States, Canada, and Australia, the people are large in stature.



*An American and a Greek*

**How can people unacquainted with principles of nutrition select a ration of a standard nutritive ratio?** Experience and the natural taste or instinct of the human being usually result in the selection of a diet that is well balanced. Persons in moderate circumstances who live in countries where food is abundant usually select a ration that approaches very closely the ideal, well-balanced ration.

The tendency to-day is toward a wider ration than is advisable, because many food substances extremely rich in protein, such as the outer layers and the germs of cereal grains, are rejected in preparing the cereals for food. As a result of the casting out of these materials we are eating larger quantities of starch and sugar than nature intended we should. Unfortunately, this excess of starch generally results from the exclusion of a large part of the protein, oil, and mineral substances which naturally are present in our foods.

**Is it advisable to weigh the quantity of foods we eat?** No. To sit down at the table with our thoughts occupied with the theories of eating, and then worry about how much of each kind of food we ought to eat, and what we ought not to eat, detracts greatly from the pleasure of eating, a sensation of great importance to digestion. We also interfere with digestion by concentrating our thoughts on subjects that are not likely to promote the digestive processes. We should be confident that those who provide us with food will provide what is best for us. Our natural tastes, corrected or supplemented by good manners, will prevent us from being gluttons, but still we should all know whether we are eating too little or too much of this or that food.

Moreover, ordinary experience in serving foods leads to a knowledge of how to regulate the quantity that each one should eat. The judicious mother always takes care that the child who is served first does not get too much and the others too little. The quantity each one receives, though not measured or weighed, is usually the amount each one ought to have. We should find it extremely annoying if at every meal we had to measure in a balance or measuring cup the exact amount of solid or liquid food we were to have.

*Weighing bread*

**Is there any great danger from eating without weighing or measuring the food?** Only under special circumstances is there any very grave danger from eating without weighing or measuring food. If a child is very hungry he is likely to ask for more of the food that is served

first in the course of the meal than he ought to have. As a rule, good manners at the table correct this tendency. It is not good manners to ask for a second helping except under special conditions. In well-regulated families there is very little danger of overeating.

**What is a good rule to observe when eating?** A good rule, if it can be conveniently followed, is to eat only one thing at a time. If we like a food for its taste and flavor there is no reason for depriving ourselves of that taste and flavor by eating it together with some other article of food. If we like the taste of meat, why do we want to mix it with that of potatoes? If we like bread, why should we destroy its taste by eating it with sirup? The French, who are recognized as authorities on foods and cooking, eat their vegetables apart from their meats.

Fish is one of the foods that should never be eaten with anything else except the condiments that are usually used in preparing such foods. No food so effectually destroys the character and flavor of other foods eaten with it as fish. No other article of food, not even the customary potato, should be eaten with fish. Even the knives and forks used and the plates on which it was served should be removed and not used for any other food.

Fowl as well as fish, though perhaps in less

degree, is better when eaten alone. It is customary to eat cranberry sauce with turkey. As a matter of fact, turkey tastes much better without it. Fowls of all kinds are commonly served with "stuffing," that is, a dressing made chiefly of bread crumbs seasoned with condiments and placed inside the turkey and roasted with it. The turkey would really taste better without it. A gravy made from the juice which drips from the fowl while it is roasting is often served. There may be some excuse for this, because the flavor of the gravy is derived from the fowl itself, but you will get the most enjoyment out of fowl by eating it alone. Pork, especially fresh pork, is commonly served with apple sauce. There seems to be no special reason for this except custom. Vegetables also best serve their purpose as foods when eaten alone.

But there are some articles so closely associated with each other that they are hardly to be considered as separate foods. I refer to the use of butter on bread or potatoes and the use of sirup and butter on hot cakes. In these cases the butter and the sirup provide necessary elements that are not present in the foods to which they are added.

At dinner to-day or to-morrow try eating the various articles of food separately. After

taking a few meals in that way you will appreciate the value of the practice. You will be able to appreciate the real excellence of each food and enjoy its taste to the utmost. You

*Sociability promotes digestion*

will also have simplified your diet, a very necessary thing for proper nutrition.

**What relation has sociability to eating?** To partake of food and drink with companions is one of the pleasures of social life. If a friend should happen to visit you, near the hour of the day when food is commonly served, the simplest dictates of friendship lead you to invite him to join you in the meal. One of the chief functions of social life is the dinner to which friends are specially invited. At social gatherings of

any kind — the meeting of a literary society, a musicale, a card party, or any similar gathering — it is customary to serve refreshments toward the close of the evening. The offering and receiving of food is a universal mark of friendship and good will.

The more pleasant the associations at the table, the more perfect are the workings of the digestive organs. Lightheartedness, pleasant conversation, and delightful companionship all promote digestion. On the contrary, care and worry, disagreeable companions, and quarreling interfere with digestion. For this reason, when we come to the table cares of every kind should be put aside, all bickerings suppressed, and all trouble as far as possible forgotten.

QUESTIONS TO HELP THE PUPIL

1. Where does the young plant get its first nourishment? Tell how you can show this. 2. When this supply is used up, where does it get its food? 3. What is necessary for life and growth? 4. Name the five principal classes of foods for animals. 5. In what other ways may foods be classified? 6. From what do we get most of the minerals in our food? 7. What vegetable contains a great deal of iron? 8. What proportion of our food should be mineral? 9. Why is it better not to discard the outer covering of fruits, vegetables, and cereals? 10. What food gives us the largest amount of protein? 11. Name other foods which contain much protein and some vegetables that contain little. 12. How can we get the exact amount of protein that we need? 13. Do proteins differ in nutritive value? 14. To what may we compare the body? 15. What are the best

protein bricks with which to build? 16. Why are rich, prosperous nations apt to use too much protein? 17. Why do growing children need more protein than grown people? 18. Between what ages should children have an abundance of protein? 19. What is the function of the starch and sugar contained in foods? 20. Besides producing heat and energy, what do the carbohydrates aid in forming in the body? 21. What common article of food contains a great deal of starch? What is the proportion? 22. What is the principal food element in cereals? 23. Name the leading starch-bearing cereals. Which contains the least? 24. What prepared foods can we get that consist almost entirely of starch? 25. At what age are carbohydrates needed most? 26. What is a varied diet and why is it best? 27. Does the builder of a house get the exact amount of every kind of material necessary to complete it? why? 28. Does this principle hold good in supplying material for body building? 29. What is the difference between an oil and a fat? What is their chief function? 30. What is meant by a balanced ration? 31. What would happen to a house if the builder had not used enough nails or mortar? 32. What are the most essential food materials? 33. How many different substances are needed for body building? Which one of the essential materials is commonly omitted? 34. What caution should we observe in the use of condiments? What proportion of our food should they form? 35. What is the standard ration of dry food for a man weighing one hundred fifty pounds? 36. How should these 640 grams be proportioned? 37. Can you tell how to determine whether a ration is well balanced? 38. What is the "standard nutritive ratio"? a wide ratio? a narrow ratio? 39. For what persons is a wide ratio best suited? a narrow ratio? 40. Is any great variation from the standard dangerous? 41. What usually governs the selection of a diet that is well balanced? 42. Tell why it is not well to mix foods when eating. 43. What articles are usually not considered as separate foods? 44. Why should there be good cheer at the table? What sort of feelings interfere with digestion?

## II. The Process of Digestion

**What is digestion?** Before foods can be used in building new tissue, in restoring wornout tissue, and in creating heat and energy, they must be broken up and dissolved so that the useful elements in them may be absorbed into the blood stream and carried with it to every part of the body. This is the work of digestion, a long and complicated process requiring delicate machinery (organs) and thousands of tiny workmen (enzymes).

### THE TEETH AND THEIR FUNCTION

**Why do we chew our food?** To be properly digested, food must first be reduced to very small particles. Liquids of course require no chewing, nor do such foods as soft puddings or mashed vegetables, except enough to separate them into smaller quantities.

The action of the teeth and the jaws is somewhat similar to the primitive or old-fashioned method of grinding grain between an upper and a lower millstone. In grinding grain only one of the millstones moves; similarly in chewing, only one of the jaws moves. In milling, however, it is usually the upper stone that moves, while in chewing it is the lower "stone."

The work of the teeth and jaws is of the greatest importance in aiding the process of digestion. So every one should know how to take care of his teeth in order that they may do their work thoroughly and well.

**Does the lower jaw move in more than one direction?** Yes, the lower jaw has two distinct motions: first, the motion up and down, by which the food is cut into pieces; and second, the motion from side to side, by which the food is ground between the surfaces of the teeth.

**Do the teeth in different parts of the mouth have different functions?** Yes. The front teeth are useful particularly in cutting the food into small pieces. They are, in other words, the cutting or incising teeth, and so are called *incisors*. By means of the front teeth we cut off a piece of food as large as we desire, and then reduce it to smaller pieces. The back teeth are called *molars*, derived from a Latin word meaning "to grind." When we cut off a piece of food with our front teeth the motion of the lower jaw is straight up and down. Thereafter, when the food is placed between the molars, the motion is up and down and also sidewise, in order both to cut and to grind the food.

**What are temporary teeth?** At birth human beings have no teeth. The infant has no need for teeth. The only food he should have is

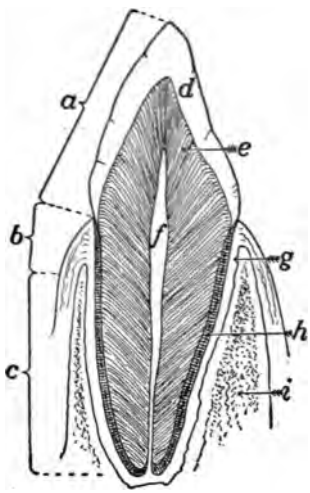
milk, and milk, we know, requires no *mastication* (chewing). At about the fifth or sixth month the first of the temporary teeth appear. These are the *incisors* or front teeth. Usually four of them come at about the same time, two in the upper jaw and two in the lower. Other teeth appear from time to time until, at the age of one year, the infant usually has eight teeth, four above and four below.

The total number of temporary teeth that appear in a child's mouth is twenty: four incisors, two *canine* or dog teeth, and four molars appear in the upper jaw and the same number in the lower jaw. The first temporary molar teeth usually appear from the twelfth to the fourteenth month, the temporary canine teeth from the fourteenth to the twentieth month, and the temporary back molars from the eighteenth to the thirtieth month.

The child begins to lose these teeth, which are called the milk teeth, from the fifth to the seventh year. At the same time the permanent molars back of the temporary molars begin to show. By the eighth or ninth year the temporary teeth are nearly all gone, and by the fifteenth to the seventeenth year most of the permanent teeth have appeared, except those farthest back in the mouth, which are called *wisdom* teeth. Sometimes these teeth do not

appear until after the age of twenty-one, and sometimes not at all.

**What is the composition of the teeth?** That part of the tooth projecting outside the gum is called the *crown* and is covered with a hard, flinty substance called the *enamel*. Below the gum there is no enamel, but in place of it is a hard, bony substance called *cement*. Inside of the enamel and the cement is the tooth substance itself, the *dentine* as it is called. In the center of the dentine is a cavity filled with the soft substance in which are the nerves and the blood vessels of the tooth.




*Vertical section of a tooth*
*a*, crown; *b*, neck; *c*, root; *d*, enamel; *e*, dentine; *f*, pulp cavity; *g*, gum; *h*, cement; *i*, jaw bone

The dentine or ivory of the tooth is composed of practically the same elements as the bones of the body. But it is much denser and for that reason much harder than the bones. About twenty-eight per cent of the elements in dentine consists of substances containing nitrogen, and the remaining seventy-two per cent of mineral matter.

The enamel, or hard outer surface of a tooth,

contains about the same elements as dentine, but the proportion of minerals is much higher, thus making the enamel still harder than the dentine. The minerals make up about ninety-six per cent of the enamel substance.

The teeth are set into little holes or sockets in the jaw bones. That part of the tooth resting in these sockets is called the *root*. The front teeth have only a single root, while the side teeth have two roots and the back teeth, or molars, usually have three roots. These roots extend into the bony structure of the jaws, holding the teeth in place with great firmness, so that they may do their work as millstones without danger of becoming loose. The part between the crown of the tooth and the root is called the *neck* of the tooth. This part is covered by the gum.

**What does "cutting the teeth" mean?** The term "cutting the teeth" is applied to the process which takes place when the teeth *erupt* or come through,— that is, when they first show through the gum. This process really is cutting the gum and not cutting the teeth. In the infant the gum is closed; that is, there is no opening through which the teeth can come. When the teeth erupt they must push their way through the gum. Though this is a natural process, the tooth growing very slowly and

the gum gradually disappearing in the path of the growing tooth, it is attended with tenderness and pain, and is often the cause of considerable irritation of the digestive organs.

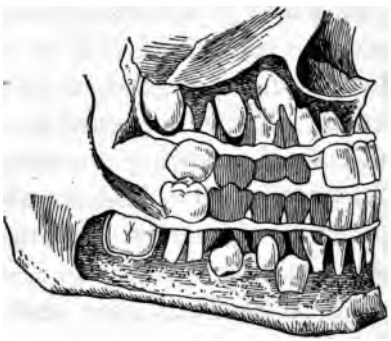
"Teething" is a process which mothers look forward to with anxiety, especially if it takes place during hot weather. Children that are born in the late spring or early summer have the advantage over those born in the middle of winter, since their first temporary teeth appear in cold weather and so cause less danger and disturbance than in the case of children whose teeth come during the summer.

When the teething process begins it is customary to give the child some soft elastic substance on which to bite. The light rubber animals so commonly used as toys are excellent for this purpose, but they should be Pasteurized, that is, heated for twenty minutes every day in water at a temperature of at least one hundred sixty degrees. This process makes the rubber safe for the child to use, and does not injure its texture.

But the child should not be permitted to do this for more than a few days. The tissues of the infant's mouth are very soft and yielding, and those who are constantly putting objects into their mouths, or who suck their thumbs, are likely to have deformed mouths, projecting

teeth, and distorted nostrils. These things may lead to mouth breathing. There is also danger of carrying disease germs into the mouth.

**What care should be taken of temporary teeth?** The temporary teeth require as much care as the permanent teeth. They are extremely important to the health of the child from infancy to the age when the permanent teeth appear. This period covers a number of years and during that time the child must depend on his temporary teeth for chewing. This period is of the greatest importance to the child, since then may be laid the foundation for lasting good health and for a strong and efficient body.



*Teeth of seven-year-old child. The milk teeth are shaded. Permanent teeth are shown growing at the roots of the remaining temporary teeth.*

A great many people do not know what a serious menace imperfect temporary teeth are to the health of the child. If a temporary tooth starts to decay, the parent is usually consoled with the thought, "Very well, let it go. The new tooth will soon take its place." Such indifference is extremely dangerous. If the temporary tooth is lost before

its time, there is danger that the permanent tooth following it will not develop properly. The germs of the permanent teeth develop early; so, if a temporary tooth is lost before its time, the germ of the permanent tooth will seek to occupy the vacant space. The germs of the permanent teeth on either side may also seek to grow into this open space.

For these reasons every care should be taken in developing and preserving the temporary teeth as well as the permanent teeth.

**How may good teeth be developed?** Good health and the right kind of food are necessary for the development of good temporary and permanent teeth. The food should be rich in bone-building and tooth-building material. For this reason the diet of the child should contain plenty of mineral substances, particularly lime and phosphoric acid. Milk is an ideal diet for the child, since it contains lime and phosphoric acid in the proportions needed to build up the bones and the teeth.

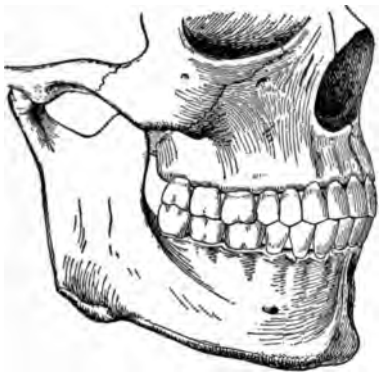
When the child begins to eat solid foods and take less milk, it should eat the foods containing the necessary amount of mineral substances. The minerals, as we have already learned, are most abundant in the outer coverings of cereals, vegetables, and fruits. So when we throw away the skins of vegetables and fruits, and

the fibrous coverings of the cereals, we deprive ourselves of mineral foods that are necessary for the development of the teeth. Young children cannot very well eat the skins of fruits or of potatoes. But the coverings of cereals, if ground very fine, are suitable foods for them. By using the proper kind of millstones the outer coat of the grain is so ground that it easily yields its mineral matters in the digestive process. Children should therefore be fed liberally with bread made from the whole grain ground fine in the old-fashioned way. Modern mills using smooth steel rollers do not grind the bran but break it into large flakes. In this form the bran is not suitable for digestion by children nor even by grown people.

**How do bad teeth endanger the health?** Many dangers threaten the health of those who have poor teeth. Children, especially, are in danger. Children with poor teeth cannot chew their food properly. The food can be cut and ground into small particles by the process of chewing only when the teeth are in good working order.

Moreover, it is of great importance that chewing should be done so thoroughly as to mix the saliva with every particle of food. The saliva aids the process of swallowing and provides the additional moisture necessary to prepare the chewed mass for digestive purposes.

The digestive substance (*enzyme*) contained in saliva rapidly changes starch particles in the food into a substance called *dextrin* and sugar. This is the first step in the digestion of starch foods. If the process of chewing is continued the enzyme in the saliva will convert much of the starch into dextrin and sugar.



*A good set of teeth*

**What other dangers result from bad teeth?** Many kinds of injurious bacteria lodge in decaying teeth. This is true especially if the decay extends down into the roots. If pus is formed it may easily be absorbed into the blood, causing very serious results.

It is almost impossible to keep a decaying tooth clean. It is hard to get at the decayed spot, which is often located between the teeth or concealed just below the gum. Even if we could reach the spot it would be difficult to remove the bacteria from it. Thus every decaying tooth, and every tooth that is so deformed that it cannot cut or grind the food as it should, threatens health.

**How may we avoid these dangers?** We must first discover the nature of the trouble. The teeth may be irregular and uneven. Very often the upper teeth project out of place. In early life such teeth may gradually be brought back into place by a skillful dentist. Very often two growing teeth are trying to occupy the same position. If it is too late in life to bring them back into place, one of them, the one that is farthest out of place, should be extracted, leaving the remaining tooth to be brought into its proper position.

Unfortunately the cost of bringing badly placed teeth into the proper position is too great for persons in ordinary circumstances. For this reason it is very important for the parent to make sure that proper care is taken of the temporary teeth, and so guard against deformities.

In nearly all cases it is possible to save the teeth from early decay by inspection, cleanliness, and prompt attention to the first signs of decay. Careful attention to this matter is the duty of every parent. It is also the duty of every young person to form the habit of keeping his teeth thoroughly clean.

**What is the purpose of dental inspection in the public schools?** The purpose of dental inspection in the public schools is to discover the condition

of each child's teeth and the nature of the tooth trouble, if there is any. In order that the school may best serve its purpose — that the children may learn their lessons, obey their teachers, and remain in good health — the teeth of every child must be inspected and dental troubles corrected. The dental inspector furnishes a card showing the character of the disease or deformity. The child brings the card to the

*A school dentist inspecting a child's teeth*

parent, who then takes it to the family dentist. By means of this card the dentist will know at once where to look for the trouble.

Parents who are not able to pay for such services can go to the public dental clinic, which provides free treatment. Such clinics are of the greatest importance to a community, and no village or city should be without one.

Many children in the public schools have never had their teeth examined by a dentist. In many cases the parents, even, do not examine their children's teeth and do not know their condition. Experience has shown that when tooth troubles are remedied, great improvement takes place in scholarship, deportment, and health. It is almost useless to try to teach children whose teeth are bad. Rather than try to teach such children, a determined step should be taken to save their teeth. If necessary, the teaching should be entirely discontinued until the teeth are saved. A child can learn his lessons next year, but he can never get back the teeth he loses.

Careful dental inspection and prompt attention to the faults it reveals, together with public support of a clinic for the children whose parents are unable to pay for such work, are of great importance to the welfare of every community and the success of every school.

### THE SALIVARY GLANDS AND THEIR FUNCTION

**What are the salivary glands?** The salivary glands are little sacs connected with the mouth by small ducts or tubes. They secrete the fluid called saliva. The saliva is constantly entering the mouth through these tubes, but the flow is especially abundant during the time of eating.

The saliva contains, as we have learned, an enzyme valuable in the digestion of starch.

There are three pairs of salivary glands. The largest pair lie one on each side near the ears. They are called the *parotid* glands, the word parotid meaning "near the ear." In the grown person they vary from one half ounce to an ounce in weight. The ducts through which the saliva enters the mouth are about two inches and a half in length.

The pair of salivary glands next in importance is situated one on each side under the lower jaw in the upper part of the neck and are known as the *submaxillary* (under the jaw) glands. The third pair of salivary glands is situated under the tongue. They are called the *sublingual* (under the tongue) glands.

The salivary glands are abundantly supplied with arteries, veins, and nerves. They are active at all times, but become very active when we are hungry, when we smell a good dinner, or when we sit down before an appetizing meal. You have all heard of the mouth "watering." This means that the salivary glands are pouring a large amount of saliva into the mouth in anticipation of the good food which the sense of smell or of sight has discovered and reported. New saliva is always gathering in the glands to take the place of the fluid that is discharged.

The gland under the tongue may be regarded as one gland, although, since it is divided by the middle line of the tongue, it is practically two separate glands. For the discharge of saliva, the gland under the tongue has a large number of ducts, varying from eight to twenty, each with a separate opening into the mouth.

Constant chewing, especially of a substance that tastes good, will cause the glands to discharge large quantities of saliva. But such continuous activity of the glands cannot be regarded as desirable. The function of the salivary glands should not be wasted by chewing gum or any other useless substance. When they are abused in this way, the glands become overworked and worn out, and so become unfitted to play their part in aiding the processes of digestion.

### A STUDY OF SWALLOWING

**How do we swallow our food?** When the food has been well masticated and thoroughly mixed with saliva, the natural tendency is to pass it back toward the base of the tongue in the form of a *bolus* (ball). From the base of the tongue it passes into the opening of the *esophagus*, the tube situated behind the windpipe and leading from the mouth to the stomach. The bolus is then swallowed. The process of swallowing

cannot be controlled by the will. It is involuntary or automatic. The fibers of the esophagus contract involuntarily and force the food into the stomach. You can keep the food from getting into the esophagus, but once it is there you cannot by any force of the will prevent yourself from swallowing it.

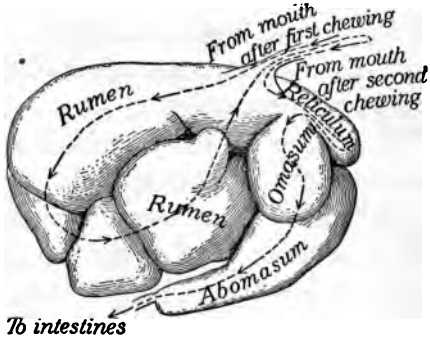
If the food, instead of going into the esophagus, should enter the passage to the lungs, violent protests would result, in the form of coughing. This is the means nature takes to drive the unwelcome substance away. Should the food become fixed or fastened in the opening of the *trachea* (windpipe) the supply of air would be cut off from the lungs and death would follow.

**Instead of swallowing, does the esophagus ever work the other way?** Yes, in certain cases of sickness nature often reverses the act of swallowing and the food is forced up through the esophagus and out into the mouth. This is called vomiting. That process is also involuntary. We cannot prevent vomiting by means of the will. But we can cause it by irritating or tickling the throat, by taking medicine which produces nausea or irritation of the stomach, or by drinking warm water, especially if it contains a little salt. Thus by mechanical means or by medicines we may aid the stomach in ridding itself

of substances which it cannot properly digest. The fibers of the esophagus reverse the action of swallowing and drive the food out again.

Ruminant animals,—those that chew the cud, like the cow and the sheep,—are provided with a special stomach. This stomach receives the food in the form of boluses produced by the process of chewing. When this stomach is full and the animal stops eating, these boluses one by one are sent back into the mouth, where they go through a second process of chewing. When swallowed the second time, the bolus passes into a second stomach.

The human being is not provided with any apparatus of this kind. We must, therefore, do our chewing well while we have the chance.



*Stomach of a cow, showing course of food*

**Is it desirable to aid the process of swallowing by using liquids while chewing?** This question of the use of liquids while chewing has been the subject of much discussion. The best authorities generally oppose the use of liquids while chewing. They claim that such liquids lessen

the activity of the salivary glands so that a decreased quantity of saliva is sent into the mouth. If we do not take liquids, and if we chew our food a little longer, greater quantities of saliva will be mixed with the food. This is especially desirable when eating starchy foods. When eating lean meats, eggs, and foods of that kind, it makes little difference whether the liquid required for the process of swallowing is provided by the salivary glands or by drinking. But it is far better to do the chewing and swallowing first, and then, if more liquid is needed in the stomach, to drink afterward. If the liquid used is a food, as in the case of milk, the objections to drinking during the meal are largely removed.

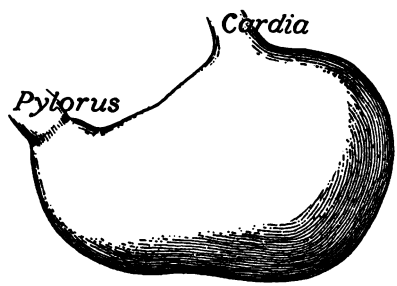
We have already called attention to the desirability of eating only one kind of food at a time. The same principle applies here. Swallow your food first; then drink afterward. But we must not forget that the food in the stomach must have a certain quantity of liquid mixed with it in order that it may be more easily acted upon by the digestive fluids.

Good sense and good advice will lead children to take the proper amount of liquids during or after the meal. But such liquids as coffee, tea, cocoa, chocolate, or beer should, of course, not be given to the child.

## THE FUNCTION OF THE STOMACH IN DIGESTION

**What is the stomach?** If you follow the Detroit River as it flows south from Detroit you will soon come to where the river widens into a lake. About two hundred miles east it contracts and again becomes a river, which rushes over Niagara Falls. Lake Erie may therefore be regarded as an expansion in a river. The stomach bears much the same relation to the esophagus, or gullet, that Lake Erie bears to the Detroit River. It is an enlargement of the esophagus and has a shape somewhat similar to that of Lake Erie.

The stomach is situated in the upper part of the abdominal cavity and is separated from the lungs and heart by a muscular partition called the *diaphragm*.

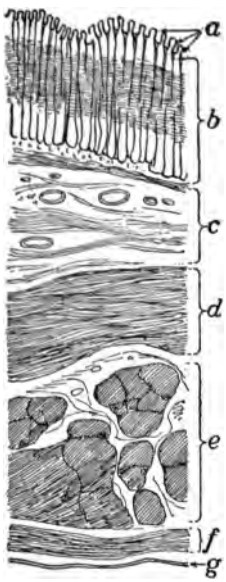


*Human stomach showing cardia and pylorus*

The esophagus enters the stomach at a point near the heart, and therefore the opening is called the *cardiac* (heart) *orifice*. The exit from the stomach, corresponding to the Niagara River, is called the *pylorus*.

The size of the stomach varies with the size and age of the individual. In the adult of

ordinary size the stomach is about twelve inches in length and four inches in diameter at the greatest point. Its weight, empty, is about five ounces. In the infant the stomach is very small, and when distended is not able to hold much more than half a pint. In the adult the stomach can be stretched considerably and can hold large quantities of liquid and semi-liquid material.




*Enlarged section of the stomach wall*

*a*, gland mouths; *b*, mucous membrane: *c*, submucosa; *d*, oblique muscular fibers; *e*, circular muscular fibers; *f*, longitudinal muscular fibers; *g*, peritoneum.

The inner coating of the walls of the stomach is a mucous membrane similar in character to the membrane inside the mouth and the esophagus. The walls of the stomach consist of four layers of muscular fibers that are capable of automatic movements, that is, movements not under the control of the will. It is by means of these automatic movements of the stomach, and the movement of the esophagus in swallowing, that the contents of the stomach are kept well mixed and are gradually forced toward the pyloric opening, where they enter the small intestine.

Because fowls have no teeth, they are provided with a very strong and muscular stomach. Chickens and ducks eat large quantities of sand and gravel with their food, and these form millstones between which the solid grains, like wheat and corn, are ground into particles.

The movements of the human stomach are very vigorous and they greatly assist the digestive processes. While these movements are automatic, they are influenced more or less by the state of mind of the individual. Attention has already been called to the fact that pleasant conversation, agreeable companionship, and attractive surroundings promote digestion. In other words, these conditions stimulate the movements of the stomach and the activity of the glands which secrete the digestive ferments. On the other hand, anger, deep sorrow, or unpleasant surroundings interfere more or less with these movements, and the process of digestion is retarded or not properly performed. Sometimes the stomach is distended or stretched too much by overeating or drinking. This unnatural pressure tends to paralyze the muscular movements, and so interferes with digestion.

If we could see the stomach during the normal process of digestion we should find it going through all kinds of contortions, as if in pain. The fact of the matter is that these are normal

churning movements performed in peace and comfort in the course of preparing the food for use in the body.

In the mucous membrane in the stomach are the openings of the glands which secrete the digestive ferments. When examined with a magnifying glass the mucous membrane looks much like honeycomb, for there are many small and shallow depressions. In these are the openings through which the fluid containing digestive ferments enters the stomach. This fluid is known as *gastric* juice. The word gastric is derived from the Greek word meaning "stomach."

**What digestive ferments are most active in the stomach?** There are two principal digestive ferments in the gastric juice. In children's stomachs a ferment is secreted which has the power of coagulating or curdling milk. This ferment is known as *rennin*. If milk remained in a perfectly liquid state in the stomach it probably would be expelled before it could be properly digested. Nature avoids this by converting the liquid milk into a mass of partly solid flakes. In this form the milk is retained in the stomach until the flakes are dissolved. In the manufacture of cheese, a substance called rennet extracted from pigs' stomachs is used to curdle the milk.

As we grow older, the amount of rennin which

is secreted decreases. Nevertheless, as soon as we drink milk, and some of us drink milk all our lives, the rennin plays an important part as a digestive ferment.

The other important digestive ferment in the stomach is *pepsin*, a digestive fluid active in the digestion of protein, converting it into a substance called *peptone*.

In the gastric juice is also an acid, known as

*Converting the white of an egg into peptone*

*hydrochloric* acid, which has important functions in the process of digestion.

We may illustrate the first step in the digestion of protein as it takes place in the stomach by a simple experiment. If we heat the white of an egg it hardens. If we now add pepsin and a little hydrochloric acid to this substance, and keep the mixture at the same temperature as that of the body, namely, ninety-eight and a half degrees, we shall see the white substance gradually dissolve. Soon all of it seems to have passed into solution, and

we know that the protein in the white of the egg has been converted into peptone.

This same process takes place in the stomach and is the principal digestive function of the stomach. Though the food in the stomach may consist of a mixture of proteins, starches, sugars, and fats, practically the only element that undergoes extensive digestion in the stomach is the protein.

The enzyme in the saliva, as we have already learned, begins to act upon starch as soon as it enters the mouth. Then when the starch has been swallowed, the hydrochloric acid in the stomach secretion gradually brings the activity of the saliva to a stop. This is because the saliva is *alkaline*, that is, it contains lime, magnesia, and soda. The enzymes found with these substances cannot act when they come in contact with acids. But it is probable that before their activity has been brought completely to a stop by the acid, most of the starch has been converted into dextrin and sugar.

The ordinary fats are not digested in the stomach, but they are probably churned up and mixed with other foods by the movements of the stomach walls.

**How do the digestive ferments act?** No one can tell how the digestive ferments act. The enzymes themselves cannot be digested. They

are little workmen who tear down or alter the structure of the food. We know that this work is done, probably with the aid of water (hydrolysis). We know it can be accomplished only by means of these ferments, that the ferments take an active part in the process, and that they are not living beings but belong to a class of substances known as *activators* or *excitors*. We have learned in our study of vitamines (Book II, pp. 51–57) that such accessories or excitors exist in certain foods, but they are not ferments.

**What causes the flow of digestive fluids?** We have already been told how the salivary glands are excited or stirred to action, especially at the thought or sight or odor of good food. All these sensations cause a flow of saliva. The activity of the glands of the stomach is also excited somewhat by the odor and taste of foods, but their activity is caused mostly by certain properties of the foods themselves after they have reached the stomach.

Among the foods that are most active in exciting the glands of the stomach are meats and meat juices. Among those that are less active are bread and the cereals. Experiments have shown that if bread is introduced into the stomach of a dog in such a way as not to suggest the idea of food, the digestive fluids of the stomach will not be secreted and the protein in

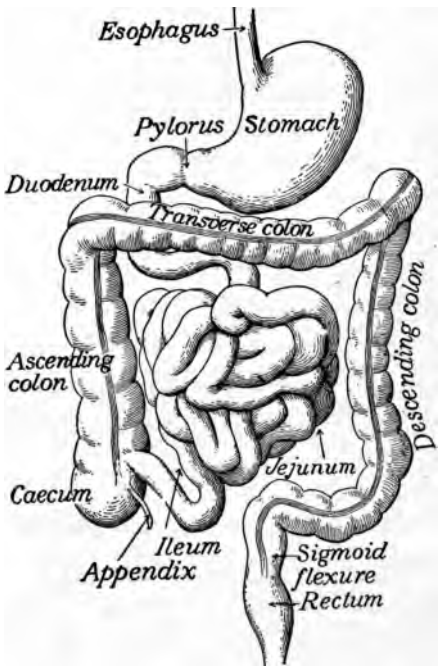
the bread will remain undigested for a long time. Some foods, therefore, have more effective properties than others in directly exciting the flow of the digestive fluids.

**How much hydrochloric acid does the stomach contain?** After the stomach is emptied of food, and before it receives a new supply, it probably contains but little hydrochloric acid. But the healthy stomach is never free from the acid.

The secretion of hydrochloric acid in the stomach is due to the same kind of excitation as that which produces the flow of the digestive ferments, pepsin and rennin. The acid first secreted after eating is absorbed by combining with the food. Gradually the acid permeates the food, and brings to a stop the action of the saliva on the starch in the food. After an hour or two the amount of acid increases and continues to increase until near the end of digestion, when the flow begins to stop.

**What is heartburn?** Heartburn is the result of too much acid in the stomach. In some forms of indigestion, usually caused by overeating or eating certain kinds of foods, a greater quantity of acid is injected into the stomach than is required for digestion. This acid causes disturbance and pain. Since the stomach is placed near the heart, the trouble was thought to be in the heart and so was called heartburn.

The proper remedy for heartburn is to avoid eating too much, and especially to avoid eating such highly spiced foods as fruitcake, plum pudding, and mince pie, which are very apt to affect some people in that way. Alcoholic drinks of all kinds, especially beer or wine, also have that effect on many people. Such articles should be avoided in order to bring about a permanent cure.



*The intestines*

**The exit of food from the stomach.** The foods, which have gone through the process of chewing in the mouth and partial digestion and mixing in the stomach, are now in the form of a thick liquid called *chyme.* This liquid passes from the stomach a little at a time into the

small intestine through the opening known as the *pylorus*. At the pylorus is a fold in the mucous membrane. This fold, opening and closing like a valve, prevents the liquid chyme from passing too rapidly from the stomach into the small intestine.

**How long does the food remain in the stomach?** Under ordinary circumstances the stomach is practically empty in from three to four hours after eating. In infants, who get nothing but milk, the digestive process goes on more rapidly; after two and a half hours the infant's stomach is practically empty. For this reason infants and children should be fed more frequently than grown people. Infants may be given six or seven meals a day. Children from two to five years of age may be given four or five meals a day. Above the age of five we can usually get along with three meals, and grown persons not engaged in hard labor can get along very well with two meals.

## A STUDY OF THE SMALL INTESTINE

**What is the small intestine?** The small intestine is a channel quite unlike that of a river in that the farther it is away from its beginning at the pylorus the smaller it becomes. The reason for this is clear. As the food enters the small intestine, and the process of

digestion continues, the food is gradually absorbed and hence decreases in quantity on its way through the small intestine.

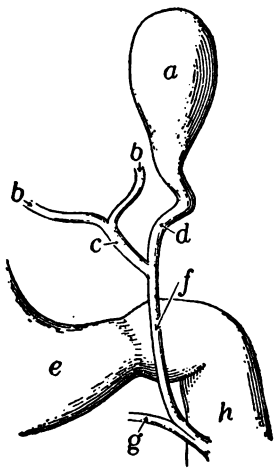
The first part of the small intestine is about as long as the breadth of twelve fingers, and so is called the *duodenum*, from a Latin word meaning "twelve each." At first it passes slightly upward from the stomach, then curves downward, approaching the spinal column. There is no very distinct mark to show the end of the duodenum and the beginning of the next portion of the intestine, which is called the *jejunum*.

The jejunum gets its name from a Latin word meaning "empty," because it was always found to be empty after death. The jejunum is about eight feet long, that is, about two fifths of the length of the small intestine. It is laid in convolutions or folds, so that it may lie within the cavity of the abdomen.

The third portion of the small intestine, the *ileum*, has its name from the Greek word meaning "to twist." It is distinguished by its numerous convolutions or coils. It is nearly twelve feet long, about three fifths of the whole length of the small intestine. In a grown person of ordinary size the small intestine is about twenty feet long.

**What is the function of the small intestine?** As we have learned, the principal digestive function of

the stomach is to reduce the protein materials in the food to the form of peptone. The function of the saliva is to start the digestion of the carbohydrates (starch and sugar). The completion of the digestive process now takes place in the small intestine.




*The gall bladder*

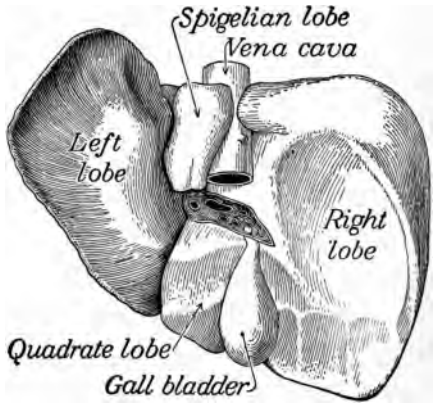
*a*, gall bladder; *b*, right and left ducts from liver; *c*, hepatic duct; *d*, cystic duct; *e*, stomach; *f*, common bile duct; *g*, pancreatic duct; *h*, duodenum

In the duodenum the food is mixed with two important digestive secretions. One of these is the *bile* or gall. The bile is separated from the blood by the organ called the *liver*. The bile collects in a pouch called the *gall bladder* and is transmitted through a tube opening into the duodenum about midway in its length. The other important digestive fluid consists of the secretions from a gland called the *pancreas*. These secretions also enter the duodenum.

The bile and the secretions from the pancreas are alkaline, and so overcome the acidity of the food as it passes through the duodenum. The food thus first becomes *neutral*, that is, neither acid nor alkaline; later it becomes alkaline as the amount of alkaline fluid in the intestine increases.

## A STUDY OF THE LIVER AND THE PANCREAS

**What is the liver?** The liver is one of the largest organs of the body. It is situated on the right side, immediately under the diaphragm. The liver of a full-grown person in good health weighs from three to four pounds. It is from ten to twelve inches long, and six or seven inches wide, and about three inches thick in its thickest part. The liver is divided into two principal parts, the right and left lobes. There are also three smaller lobes.



*The liver*

The liver is provided with a remarkable series of blood vessels (arteries and veins), for in addition to its function of separating the bile from the blood it brings about many changes in the nutrients which are carried to it in the blood. We have been told how the proteins and the carbohydrates digested in the small intestine are carried to the liver by way of the portal vein. In the liver these products undergo further

changes and are then sent out to all parts of the body by way of the blood stream. The liver bears practically the same relation to the introduction of nutriment into the body as do the lungs to the introduction of oxygen into the body.

The amount of sugar circulating in the blood is determined by the liver. This amount is very small. Most of the sugars that are formed by the digestion of the carbohydrates in our food are not needed for immediate use. So, instead of being sent into circulation all at once, they are stored away after being changed by the liver into a sugar-producing substance known as *glycogen*. Glycogen may be regarded as a reserve supply of carbohydrates. Little by little it is changed back again into sugar and sent into the blood, where it is burned according to the needs of the body. Thus we see that it is not necessary to eat sugar or starch constantly in order to supply fuel to the body, for when we eat more than is needed at a certain time the excess is at once stored away to be used at another time.

Glycogen is not stored solely in the liver. It is found elsewhere, especially in the muscular tissues of the body. In certain kinds of meat, such as that of the horse and the lobster, there is a large amount of glycogen, so much so indeed that such meats taste sweet. The liver also

changes into sugar certain products of protein digestion.

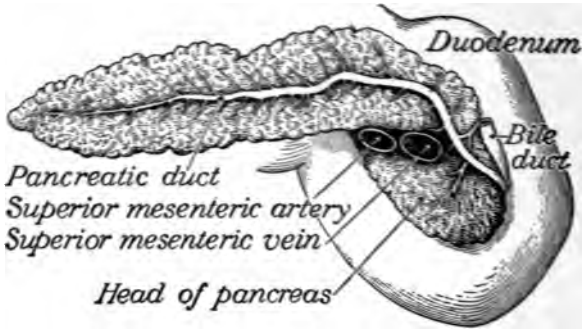
**What other important function has the liver?** The liver has a very important function as an excretory organ. Bile, for instance, which is secreted by the liver, is largely a waste product, though it also has important digestive functions. Urea, which is excreted in the urine, is also manufactured chiefly in the liver from the final products of the digestion of proteins. The kidneys separate it from the blood and pass it on to the bladder, whence it is excreted.

**What is bile?** In one sense bile is a waste product, separated by the liver from the blood for the purpose of eliminating it from the body. In the second place it has important digestive functions and in many ways performs the same functions as pepsin in the stomach and the secretions of the pancreas.

The formation of bile in the liver is probably a continuous process. But it is not poured continuously into the small intestine. In man and in some animals it is stored up in the gall bladder, from which it is poured through a duct into the duodenum.

**What is the pancreas?** The pancreas is a long, narrow gland lying in the upper part of the abdominal cavity near the duodenum. The

**secretions from the pancreas enter the duodenum through a tube or duct which unites with the duct leading from the gall bladder. The daily**




*The pancreas*

quantity of secretions from the pancreas in a man of average size ranges from a little over a pint to almost a quart.

**What digestive ferments are secreted by the pancreas?** One of the important digestive ferments in the fluid secreted by the pancreas is *diastase* or *amylase*. This has the same property as the enzyme called *ptyalin* in saliva, which we know begins the digestion of the carbohydrates. Another important ferment from the pancreas is *trypsin*. This ferment acts on the peptone, the substance formed from the digestion of protein in the stomach. Thus trypsin is closely related to pepsin. The pepsin begins the work of digesting protein and the trypsin completes it.

We have learned that the fats are not digested

in the stomach. But when they enter the small intestine the third important ferment in the secretion from the pancreas, known as *lipase* or *steapsin*, begins the digestion of the fat foods.

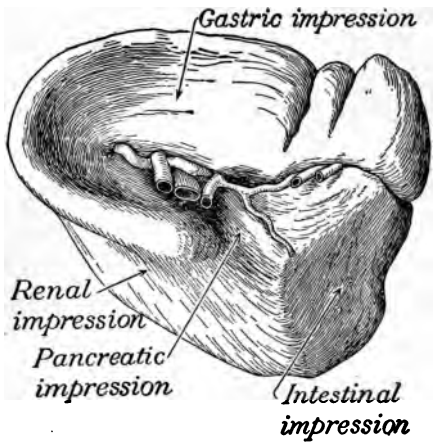
Thus it is seen that three separate kinds of digestion take place in the small intestine. The peptones are broken up by trypsin into elements called *amino* acids; the carbohydrates (starch and sugar) are broken up by the diastase or amylase into *maltose* (malt sugar), *dextrose* (right hand sugar), and *levulose* (left hand sugar); the fat is reduced by the lipase or steapsin to *glycerin* and fatty acids.

All these dissolved products now form a milky fluid called *chyle*. In that form the foods are readily absorbed through the thousands of little vessels which line the walls of the small intestine. These vessels then carry the foods into a common stream that is poured into the blood and so carried to every part of the body.

## A STUDY OF THE SPLEEN

**What do we know about the spleen?** The spleen is situated on the left side, and very near the end of the stomach that is turned toward the heart. For many years the spleen was a mystery to those studying the growth and development of the body. It was thought to be an organ without a function, because it had no

duct by means of which its secretions could reach any part of the intestines. By some it was thought to be the seat of bad passions, such as anger and envy.



The spleen

A later study of the spleen has brought out the fact that it goes through certain changes in size which keep step with the taking of food into the stomach and the process of digestion. After we have eaten, the spleen increases in size, continues to increase for several hours, and then slowly returns to its original size. Thus it is evident that in some way the spleen is in sympathy with, or is affected by, the process of digestion.

The presence of certain substances in the spleen which are important in the nourishment of the body is another reason for believing that the spleen plays an important part in nutrition. The organ is also thought to have important functions in connection with the red corpuscles of the blood, for they seem to undergo certain

changes when in the spleen. But it is certain that of all the organs of the body of any size the spleen must be regarded as the least important, since it has been found that if it is cut out of the body, life is not necessarily endangered by its absence. Animals continue to live and remain apparently in good health after the spleen has been removed.

In a grown person weighing one hundred fifty pounds, the spleen weighs approximately one half pound. In very old persons its weight diminishes in proportion to the weight of the body. In certain diseases it becomes much enlarged, and has been known in extreme cases to weigh twelve or fifteen pounds.

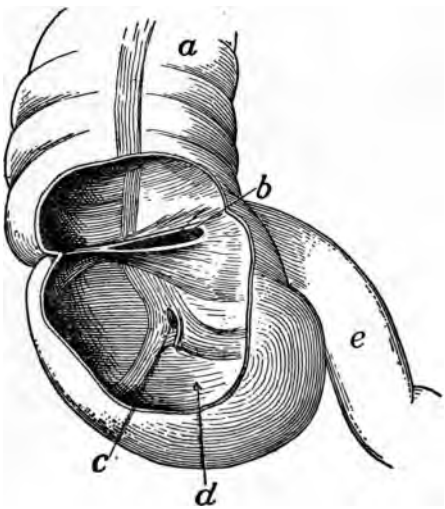
We know less, perhaps, about the functions of the spleen than about the functions of any other important organ in the body.

## A STUDY OF THE LARGE INTESTINE

**What is the large intestine?** When the food has passed through the small intestine and most of the food elements have been absorbed, the remainder enters the large intestine, which may be described as a secondary stomach. A comparison has been made between the stomach and Lake Erie. In like manner the large intestine may be compared to Lake Ontario. The entire food canal, including the mouth, the

esophagus, the stomach, the small intestine, and the large intestine, is known as the *alimentary* canal, alimentary being derived from a Latin word meaning "food" or "nourishment."

The first part of the large intestine resembles a pouch, and is called the *caecum*. Two folds of membrane guard the opening from the small intestine into the caecum, keeping the digested food from returning into the small intestine.




*Colon, caecum, and ileum*
*a*, ascending colon; *b*, ileo-caecal valve; *c*, orifice of appendix; *d*, caecum; *e*, ileum

The passage of the food through the small intestine is quite rapid. Now as it pours into the large intestine the rate of progress is at once greatly reduced. It is evident, therefore, that the object of the large intestine is to receive the contents of the small intestine and hold them until a convenient time for their excretion.

In addition to the caecum, other parts of the

large intestine are the *ascending colon*, so called because this part leads upward; the *transverse colon*, which crosses the abdominal cavity from one side to the other; and the *descending colon*, the part which leads to the end of the intestinal canal, the *rectum*.

The caecum receives from the small intestine not only the excess food but also any remaining enzymes, alkaline substances, and waste products that may be present. If there is any undigested food, the digestive ferments carried with it into the large intestine may continue their work for some time, though always with less and less activity.

The principal material absorbed in the large intestine is water. The contents of the intestine therefore become firmer and harder as they pass upward through the ascending colon, across the body through the transverse colon, and down to the rectum through the descending colon. At this point the contents of the large intestine are called *feces*. After the feces have been retained in the large intestine for a varying period of time, they are voided from the body, the final chapter in the complete history of the food in its course through the body.

**Are active organisms present in the large intestine?** The contents of the large intestine favor the development of vast numbers of very small

organisms, known as *bacteria*. They exist in such enormous numbers that a considerable part of the feces in the rectum may be made up of these small vegetable growths.

These bacteria act particularly on any remaining protein matter in the contents of the large intestine, forming products consisting of liquid, solid, and gaseous substances. The most important of these substances in regard to their effect on health are *indol*, *phenol*, and *skatol*. Phenol is the chemical name of carbolic acid. Indol is related more or less closely to indigo. Skatol is distinguished by its bad odor.

These products pass into the blood to a large extent through the walls of the large intestine, and are finally separated from the blood by the kidneys and sent to the urine. All these products are found in normal, healthy persons. They are regarded as dangerous to health if formed in too large quantities or if kept too long in the body.

QUESTIONS TO HELP THE PUPIL

1. Why must food be digested? 2. To what process can you compare the act of chewing? 3. Which jaw moves when you chew? 4. Which of the stones in the old-fashioned mill moves, the upper or lower? 5. What is the use of the front teeth? What are they called? 6. What are the molars? 7. At what age does the child's first teeth appear? 8. How many temporary teeth are there? 9. Name other teeth besides the incisors and the molars. 10. When does the child begin to lose the

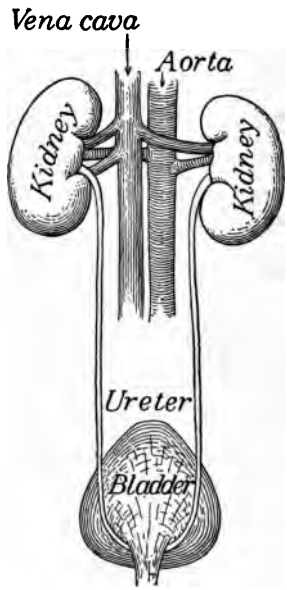
temporary teeth? 11. At what age have all the permanent teeth appeared? 12. What are "wisdom" teeth? 13. What is the enamel of a tooth? the cement? 14. What is the principal tooth substance? 15. Where in the tooth are the nerves and blood vessels? 16. What is the function of the roots? 17. What are the uses of saliva? 18. Describe the salivary glands. 19. How does the saliva enter the mouth? 20. What is an involuntary process? Name one. 21. Through what tube does the food pass to the stomach? 22. What would happen if the food should enter the windpipe? 23. What is another name for the windpipe? 24. What is a bolus of food? 25. What animal chews the cud? How do the cow's jaws move? 26. What is the diaphragm? 27. To what may we compare the stomach? 28. What is the ordinary size of an adult's stomach? 29. Of how many layers do the walls of the stomach consist? 30. By what means is food mixed and sent on through the stomach to the pylorus? 31. What glands do we find in the mucous membrane lining the stomach? 32. What are the two principal digestive ferments in the stomach? 33. How does rennin act on milk? 34. What is the function of pepsin? 35. What acid is secreted in the stomach? 36. May children be fed more often than grown people? why? 37. What is the purpose of the fold at the pylorus? 38. What is the ordinary length of the small intestine in a grown person? 39. From what organs are digestive ferments sent into the small intestine? 40. Is the food acid or alkaline when it passes from the stomach into the small intestine? 41. How is it changed here? 42. What are the functions of the liver? 43. What is glycogen? 44. From what is urea manufactured? 45. What important digestive fluid is secreted by the liver? 46. How do the digested or dissolved food products get to all parts of the body? 47. Why was it believed that the spleen had no function? 48. Where is the spleen located and how does it act during the process of digestion? 49. Why can the spleen be regarded as of little importance? 50. What part of the intestines does the food enter after leaving the small intestine? 51. How does

the rate of progress of the food change as it enters the caecum? 52. What is the main object of the large intestine? 53. What vegetable growths or organisms are present in the large intestine? 54. What is the work of these bacteria? 55. What work do the kidneys perform?

56. What do we mean when we say a child is "cutting teeth"? 57. What is usually given the child when cutting teeth? What is the danger of this? 58. What is the danger of losing a temporary tooth too early? 59. What food contains minerals in the proportions needed to build up bones and teeth? 60. Why is bread, made of the whole grain ground in the old-fashioned way, good for children? 61. Why must food be thoroughly chewed? 62. What may lodge in the cavity of a decayed tooth? 63. How may we avoid having bad teeth? 64. Have your teeth been inspected by the school dental inspector? 65. What kind of food requires saliva for digestion? 66. What is the best rule to follow in the use of a beverage at a meal? 67. Why does overeating interfere with the stomach movements? 68. What foods are most active in exciting the glands of the stomach? 69. What is heartburn? What causes it and what is the remedy?

## III. A Study of the Kidneys

**What is the function of the kidneys?** The kidneys are situated in the lower back part of the abdominal cavity, one on each side. They are connected with the bladder by excretory tubes. The function of the kidneys is to separate wastes from the blood and pour them into the bladder in the form of urine for excretion from the body. In the urine besides water is excreted the excess of mineral salts that have been taken in with the food, after they have served their function in the body; also the waste substance, urea, which is formed from the final products of protein digestion; the sulphuric acid compounds of indol, skatol, and phenol; and finally uric acid.



*The kidneys, bladder and ducts*

The principal constituent of the urine is urea. Urea, although a normal product of the breaking up of protein substances in the system, must be promptly eliminated from

the blood. It is to the kidneys that we owe our safety from acute and fatal poisoning with urea, as well as from other disorders. If the kidneys cease to act, as is the case in some diseases, death follows within a short time. The kidneys are therefore very important from the point of view of health.

The kidney is about four inches in length, two inches in breadth, and one inch in thickness. The left kidney is somewhat longer and thinner than the right. The right kidney, however, is situated a little lower down in the abdominal cavity than the left, because of the large space required by the liver, which lies just above it.

The excretory duct of the kidney is called the *ureter*. It leads from the kidney to the bladder. The duct leading from the bladder is called the *urethra*. The quantity of urine excreted is determined largely by the character of the diet and the amount of water, or other liquids composed chiefly of water, that the individual drinks.

**What are some of the common diseases of the kidneys?** There are two common diseases of the kidneys. These are very troublesome and dangerous and are due perhaps to causes entirely external to the kidneys themselves. We have learned that in the normal nourishment of the body the sugars are burned, forming chiefly carbon dioxide and water. Sugars, therefore,

are not found as normal excretions in the urine.

There are certain conditions that may favor the appearance of sugar in the urine for a short time. For instance, the eating of enormous quantities of sugar may cause a temporary excretion of sugar in the urine. There are also certain temporary disorders, during which sugar may be excreted. In good health and with a well-ordered diet the sugar is entirely burned.

There is a disease, called *diabetes*, which is characterized by the presence of large quantities of sugar in the urine. While it is usually spoken of as a kidney disease, it is more properly a diet disease. It can be controlled to a great extent by diminishing the amount of sugars and starches in the food.

We have learned that protein matter normally digested in the body is reduced to the form of amino acids, in which form it is built up into the tissues of the body and finally broken into the substances composing urea. There are certain disordered conditions of nutrition in which soluble protein, known as albumin, is separated from the blood through the kidneys and appears in the urine. This condition may be a dangerous form of disease and should receive prompt medical attention. The disease is known as *Bright's disease* from the name of the physician who first described it accurately, and

is spoken of as a kidney disease, when perhaps the kidney is without blame in the matter and the trouble really comes from disordered conditions of nutrition.

The proper functioning of the kidney and the proper evacuation of the bladder are necessary to health, and the principles on which the activity of these organs depends should be taught to all in order that health may be preserved.

QUESTIONS TO HELP THE PUPIL

1. Describe and locate the kidneys. 2. What is their work? 3. What disorder of the kidneys does eating large quantities of sugar sometimes cause? 4. What are two dangerous diseases of the kidneys? 5. What would be the result if the kidneys should fail to act? 6. How large is the kidney? 7. Explain the connection between the kidneys and the bladder. 8. What should be taught to all? why?

## IV. How Foods Are Absorbed

**How do nutrients obtained by the process of digestion pass into the blood?** It is not difficult to get a general idea of how the nutrients — substances which promote growth — obtained by the digestion of foods are absorbed. The whole alimentary canal is lined with what is known as *mucous membrane.* This mucous membrane constantly secretes a fluid consisting mostly of water and containing a viscid (sirupy or ropy) substance. This fluid is called *mucus.* Usually the mucus is colorless but sometimes, when secreted in large quantities or if secreted from certain membranes, it is milky or even yellowish in color. Mucus is necessary to the proper activity of the whole alimentary canal, aiding the digestive secretions from the stomach, the pancreas, and the gall bladder in dissolving the food substances. Anything that interferes with the normal secretion of mucus tends to cause or promote disease.

In addition to the mucous glands and the openings through which the digestive secretions enter the intestines, the mucous membrane, especially in the small intestine, is supplied also with an extensive system of absorbing vessels. Thus substances pass in both directions through

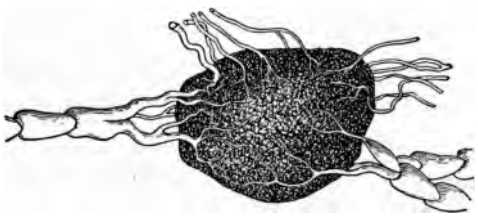
the mucous membrane, the digestive ferments and the mucus entering the intestine, and the digested foods and water passing out.

**Are food products absorbed in the stomach?** Though digestion takes place in the stomach, little food is absorbed there. On the other hand, certain substances that cannot be regarded as true foods are readily absorbed. The most important of these is alcohol. Water, which is so important to the digestive process, is not absorbed in any quantity through the walls of the stomach unless alcohol is present. Small quantities of certain sugars in our foods are probably absorbed, but it is doubtful whether this is true of any of the fats.

**Where are foods principally absorbed?** The principal system of vessels provided for the absorption of food is distributed throughout the mucous lining of the small intestine. Slender projections, known as *villi*, cover this lining. In these are spread millions of tiny *capillaries*, which take up the products of the digestion of the carbohydrates and also of protein. These products are then conveyed into the blood stream and carried through a tube known as the *portal vein* leading into the liver.

A portion of the sugar is retained in the blood and passes immediately from the liver to all parts of the body to be burned for the purpose

of producing heat. The remainder is converted into *glycogen* (sugar producer) and stored away, to be given up little by little in the form of sugar as conditions may require. The blood must always contain a certain amount of sugar at all times. It has been estimated that a thousand parts of blood carry only about fifteen parts of sugar. For this reason one of the chief functions



*A lymphatic gland*

of the liver is to receive the whole mass of carbohydrates (sugars) as they are digested, and send them into the blood in the proper quantities.

**How are the fats absorbed?** A second system of absorbers is present in the villi. These are suited to the absorption of digested fats. They are called *lymphatics*, or *lacteals* from a Latin word meaning "milk," because when the fats are absorbed they form a milky emulsion. The contents of the larger absorbing vessels become whitish in appearance when food containing a large quantity of fat is absorbed. The fats are carried through the lacteals into a large tube which in turn empties into the blood stream.

There is no doubt that a part of the digested protein is absorbed by the same vessels that take up the fat, and that it enters the circulation together with the fat. In fact, it is not improbable that neither system of absorbers is engaged exclusively in taking up a certain food product.

While the greater part of our food is absorbed in the small intestine as described, we should not forget that the mucous membrane probably has a slightly absorbent effect throughout the alimentary canal, with the possible exception of the mouth and the esophagus.

**Are certain kinds of protein more easily absorbed than others?** Experience has shown that certain proteins, especially those contained in milk and eggs, and to a certain extent those found in meats, are more readily and completely absorbed than some others. It is believed that ninety-five per cent or even more of the protein of milk, eggs, and meats, eaten in normal quantities, is digested and absorbed.

On the other hand, the gluten of wheat, the zein of corn, and the *hordein* of barley are not absorbed so completely as the protein in milk or in meat. The protein in bran, especially, is not absorbed in large quantities. The reason for this difference lies not so much in the nature of the protein itself as in the fact that the vegetable proteins are incrusted with a substance

known as *cellulose* as well as with other substances that are difficult of digestion (*peritosans*), and so protect these proteins more or less from the action of the digestive ferments.

**How are mineral substances absorbed?** The mineral substances we eat are doubtless absorbed in the various ways in which the proteins, the carbohydrates, and the fats are absorbed. Common mineral substances (salt, phosphates, lime) are not readily absorbed in the stomach unless they are present in large quantities, and it is not likely that common salt will be eaten by any one in very large quantities.

The use of condiments in our food has a stimulating effect on the absorbent action of the mucous membrane of the stomach and doubtless also of the small intestine.

QUESTIONS TO HELP THE PUPIL

1. What membrane lines the inside surface of every portion of the alimentary canal? 2. What fluids are secreted by this membrane? 3. Where does the greatest absorption of food take place? 4. What are the villi? 5. What are the capillaries and what is their use? 6. What is the use of the portal vein? 7. What are the absorbers called that take up the fat and oil products? 8. Why are these absorbing vessels called lacteals? 9. What duct or tube carries these products into the blood stream? 10. What proteins are most readily absorbed? 11. Why are the cereal proteins not so easily absorbed as the proteins in milk, eggs, and meats? 12. How are mineral substances absorbed? 13. Do condiments aid absorption in the stomach?

## V. The Blood Stream

**What is the blood?** The blood is the liquid which flows through the arteries and veins of the body, carrying nourishing materials with which to build tissues and to make them grow. It also carries the oxygen by means of which the heat and energy of the body are produced, and the mineral salts which maintain the blood in an alkaline condition and thus keep the muscles of the heart active in propelling the blood through the arteries. The blood also carries to the proper organs waste products, such as water, carbonic acid, urea, and used-up mineral salts.

**What are the chief constituents of the blood?** Water is the most abundant constituent of the blood, its proportion being nearly eighty-one parts in a hundred. Besides water, blood contains nitrogenous materials called *plasma.* In blood that has been removed from the body, the plasma hardens, forming what is called a "clot." If the clotted blood is washed with water, a fibrous substance known as *fibrin* is separated from the other contents of the blood. It is found to be of a yellowish-white tint. The other substances in the plasma after the fibrin has been separated form a liquid called *serum.*

**How soon does the blood clot after it leaves the body?** The blood of different individuals varies greatly in this respect. It also varies in the same person, according to the state of health. In some diseases the blood, when removed from the body, does not clot at all. In others, the blood clots while it is still in the body. In the latter case the clots lodge in the valves of the heart and death speedily follows.

The usual time required for healthy blood to clot after it flows from the body is from five to ten minutes.

**What are other constituents of the blood?** The blood is full of disk-like bodies of minute size which can be seen only with the aid of a magnifying glass. These bodies are called *corpuscles*. They are of two kinds, the red disks and the white disks. The red disks are really the oxygen carriers of the blood, and the white disks are especially active in safeguarding the health of the body. They are the policemen already referred to.

**How do white corpuscles guard against disease?** The white corpuscles were for many years objects of much speculation. Their true function was not known positively until a short time ago. The white corpuscles seem to have a life of their own, and to be able to govern their own movements. They do not remain at

rest and are not satisfied to be carried along mechanically by the blood stream, but make little journeys on their own account. It is believed that these white cells have the power to destroy the germs of disease which enter the blood. In other words, they act as policemen, and when a disease germ enters the blood it is their duty to arrest it and either drive it out or destroy it.

**What is the chief function of the blood?** The blood of an animal, as the Bible says, "is the life thereof." Blood and life mean almost the same thing. The blood stream is the life stream. The blood distributes to all parts of the body not only the materials that are necessary for growth and repair, but also those that provide heat and energy. The blood also carries the oxygen that is necessary to the vital functions. Finally it carries away the waste materials from the broken-down tissues.

The blood in a healthy state, flowing away from the heart through the arteries, carries a large volume of oxygen and carbon dioxide loosely combined with the coloring matter. It is then a brilliant red. When the blood returns to the heart through the veins it carries less oxygen but a very considerably increased quantity of carbon dioxide. This fact is demonstrated very beautifully by the change of color which the blood undergoes when it passes from

the capillaries leading to the arteries to the capillaries leading to the veins. The change of color is from a brilliant red to a dull purplish blue.

It is certain that the blood in a healthy state never loses all its oxygen, nor all its carbon dioxide. There is a normal minimum amount of carbon dioxide in the blood, and a normal maximum amount of oxygen. The venous blood carries approximately half its volume, or about forty-five per cent, of carbon dioxide. This is reduced to thirty-eight per cent in the arterial blood.

If any very great change takes place in the blood to increase or diminish the minimum or maximum content of carbon dioxide or of oxygen, serious troubles or even fatal results may occur. Nature's system of breathing pure air is the best known means of maintaining the proper balance.

**What happens when there is too much blood in the body?** If both the volume of the blood and the soluble substances contained therein are increased beyond the normal because of an over-generous diet and the drinking of large quantities of liquids, a greater effort than usual is demanded of the heart. The pressure which the blood exerts on the heart and the arteries is increased. As the physician says, "the blood

pressure is high." The blood pressure may be very easily measured by wrapping the arm with a rubber or other air-tight envelope to which a delicate measuring instrument is attached. Air is now pumped into the air-tight envelope until a sufficient pressure is produced on the arm to stop the pulsation at the wrist. When the pulsation at the wrist can no longer be felt, the measuring instrument will give the measure of the blood pressure.

In youth and in early life the blood pressure is usually very low. As we grow older, and the walls of the arteries get firmer, the blood pressure increases. If the arteries are diseased so that their walls are thickened and very much hardened, the blood pressure is increased. When the blood pressure reaches one hundred sixty millimeters of mercury we know either that old age is coming on, that there is too much blood, or that the artery walls are becoming too thick. A pressure of one hundred eighty to two hundred millimeters is evidence of a grave disease which must be carefully treated. In such cases, if the thickening and hardening of the artery walls has not proceeded too far, prompt relief may usually be gained by reducing the diet, and especially by omitting meats and eating only simple cereals, fruits, nuts, and vegetables.

One of the principal dangers of a high blood pressure is the effect on the heart. The increased labor of the muscles of the heart and the pressure on its cavities cause the heart to enlarge, and such enlargement is usually dangerous.

**What happens if there is too little blood in the body?** If the volume of blood in the body becomes less than normal, or if the blood is thinned by the extraction of any of its normal ingredients, the health of the body is endangered. The condition of the blood can be determined by measuring the blood pressure, and by a chemical and microscopic examination. If it is too thin, a great lessening of the coloring matter of the blood is often noticeable, showing that practically all the contents of the blood are becoming poorer in quality. This condition causes paleness, colorless lips, a cessation of growth, general apathy and indifference, a lack of desire for exercise or work, and inability to prepare lessons or to do any mental work. The name physicians have given to the trouble is *anemia.*

Thin blood or too little blood is a very serious matter. In fact, it is a disease, and should receive careful medical attention. Usually some fault in the diet or disease of the organs of digestion is the cause of such disorder. A diet of fresh, clean milk, fresh eggs, fruits, vegetables,

and fresh poultry or meat, properly cooked, will very often entirely remedy the trouble.

**What are "blood purifiers"?** A great many patent medicines claiming that they will purify the blood are offered for sale. "Purifying the blood" is a phrase that has no definite scientific meaning. The blood is said to be impure whenever it carries too much or too little food or the germs of disease. Impure substances in the blood are usually enzymes or are poisons produced by the work of bacteria. The blood may also carry certain organisms, for instance the germs which produce malaria or chills and fever. Other living organisms may be present in the blood, producing specific diseases. Thus any scientific method of purifying the blood must be based on an understanding of what the impurity is.

It is evident that none but a scientific man who has made a specialty of the subject can discover whether there are impurities in the blood and what they are. This he does by means of certain chemical tests, with the microscope or in other ways. No one but the trained physician who understands the nature of the disorder can prescribe for it.

The common so-called blood purifiers are usually mild cathartics by means of which the alimentary canal is thoroughly evacuated; or they may consist of certain herbs and roots

which have little or no effect in improving the condition of the blood. Beware of secret blood purifiers. As a rule they are fraudulent, and sometimes they are extremely injurious.

**What is the relation between the condition of the blood stream and "spring fever"?** An expression commonly heard in many parts of the country is "spring fever." In the first warm days of early spring many people, both young and old, complain of feeling tired and lose all desire for active exercise or hard work, mental or physical. Strictly speaking, this feeling is not a disease, though it is called "spring fever."

The feeling of weariness in spring is due wholly to the increased temperature or to faults in the diet. In cold weather we should eat a much larger amount of food, especially heat-giving foods, than we do in warm weather. This is in order to supply additional warmth, since the heat of the body radiates, or is given off, so rapidly in the cold atmosphere. When spring comes on and it has grown warm, if we continue these habits of eating we consume more food than the blood stream needs. To rid the blood of the excess food the body uses up much of its vitality, so that one is likely to feel indolent and tired.

As the warm weather comes on, the amount of food eaten, by grown people as well as by

children, should be promptly diminished. This will in a measure prevent the feeling of weariness. The stimulation produced by the cold temperature of winter is also lacking in the warm days of spring, thus adding to the trouble.

### QUESTIONS TO HELP THE PUPIL

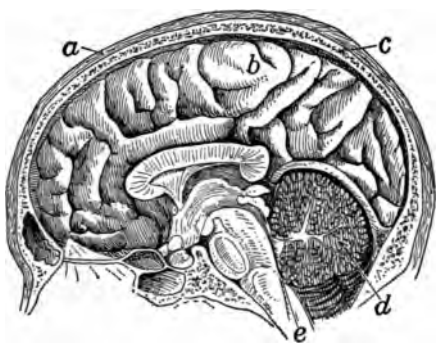
1. What is the result of any change in the normal amount of carbon dioxide or of oxygen in the blood? 2. What is a "blood purifier"? 3. When is the blood said to be impure? 4. What is it necessary to know about a disorder of the blood before any one can prescribe a remedy? 5. Why should so-called blood purifiers be avoided? 6. How can the blood pressure be measured? 7. Tell how you may find out if there is too little blood in the body. 8. What is the name of this trouble? 9. What diet is good in cases of anemia? 10. What is "spring fever"? 11. To what is this feeling of weariness due? 12. How may spring fever be prevented?

13. What materials does the blood carry away from the lungs? to the lungs? from the digestive organs to the tissues? to the excretory organs, the liver and the kidneys? 14. What proportion of the blood consists of water? 15. Of what does plasma consist? 16. What is the fibrous substance in the hardened plasma? 17. What remains when the fibrin is removed from the plasma? 18. What do corpuscles resemble? 19. What is the function of the red corpuscles? of the white corpuscles? 20. What is the color of the blood when it returns to the heart through the veins? 21. What is the color of the blood when it is carrying a supply of oxygen through the arteries? 22. Does the blood lose all its carbon dioxide when it reaches the lung cells? 23. What is the normal minimum amount of carbon dioxide in the blood? 24. What is the effect on the heart and the arteries of too much blood? 25. What does a high blood pressure sometimes show as to the condition of the arteries? 26. What is the effect of high blood pressure on the heart?

# VI. A Study of the Nervous System

## THE BRAIN

**What are the functions of the brain?** This is a very difficult question to answer, yet a perfectly natural one to ask. The brain is located within the skull. It is a mass of delicate tissue, arranged in lobes and folds, richly supplied with blood vessels, and covered with a heavy, tough membrane. That the brain is a very important organ is shown by the fact that nature has surrounded it with a fort or shield of bones to protect it from injury, blows, sudden changes in temperature, and other harmful influences. The shield of bones surrounding the brain is more or less spherical, and is completely closed except for a number of perforations in the under surface and the surface toward the face. These openings admit




*A section of the skull showing the brain*
*a*, scalp; *b*, cerebrum; *c*, skull; *d*, cerebellum; *e*, medulla oblongata

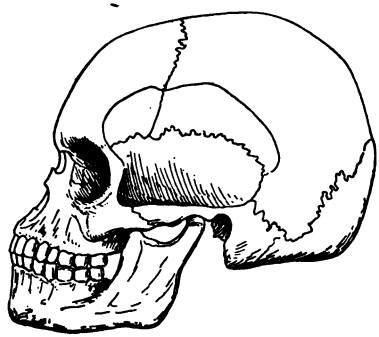
the spinal cord, various nerves, and the arteries and veins that carry blood to and from the brain.

*The skull, showing the bones*
*a*, frontal; *b*, parietal; *c*, temporal; *d*, sphenoid; *e*, malar; *f*, superior maxillary (upper jaw); *g*, occipital; *h*, inferior maxillary (lower jaw); *i*, nasal: *j*, ethmoid; *k*, lachrymal

Although the term "skull" really includes all the bones of the head, it will be used in this discussion with reference only to that portion inclosing the brain. At the points most exposed to danger—as, for instance, the forehead and around the ears—the brain is provided with additional protection. Between the bony layers of the forehead over the eyes is an open space, so that if you puncture or pierce the outer layer of bone the inner layer may still remain uninjured. The bones back of and around the ears are also thickened for purposes of protection.

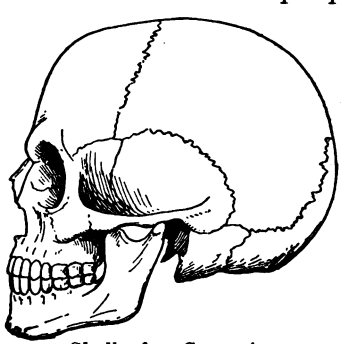
The outside of the skull is covered with the skin and the hair, which also aid in protecting the brain.

Altogether, there are twenty-two bones in the structure of the head. Eight of these form the skull, the shield inclosing the brain. In infancy the bones of the skull are not joined. Between them are spaces composed of flexible substances that gradually harden into bones as the child grows older. In the grown person the skull bones are usually so firmly united as to form practically a single bone.



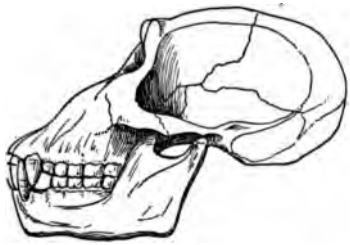
*Skull of a Negro*

The skull varies in size. The skulls of educated and civilized people are thought to have a larger capacity than those of ignorant or savage peoples. But the prevailing idea that the size of the brain indicates the amount of intelligence is by no means true. Yet idiots and others of arrested mental development usually have small brains while many men of great mental powers have large brains.



*Skull of a Caucasian*

The brain is supposed to be the organ of mental activity. Our intellect, in other words, is so closely associated with the functions of the brain as to warrant the statement that intelligence is directly due to the working of the brain. You may lose your foot or your hand or your leg or your arm without in any way affecting your mental and intellectual vigor. But the moment the brain is attacked, intelligence diminishes, mental power decreases, and mental activity may cease altogether.



*Skull of a chimpanzee*

The brain consists of four general divisions: First, the large brain, called the *cerebrum*, occupying the greater part of the skull cavity and lying toward the front and the top of the skull. Second, the small brain, called the *cerebellum*, lying at the base and toward the back of the skull. Third, the expansion of the spinal cord within the skull, called the *medulla oblongata*. Fourth, the bridge-like structure at the base of the brain, called the *pons* from a Latin word meaning "bridge" and forming connecting links between its parts.

**What is the total weight of the brain?** In a grown man of average size the brain weighs about fifty

ounces. In a woman it weighs about forty-five ounces. The weight of the brain varies in different individuals, but usually the variation from these figures is not more than about four ounces. Occasionally a man has been found with a brain weighing sixty-five ounces or more, and once in a while a woman with a brain weighing from forty-eight to fifty ounces.

## THE SPINAL CORD

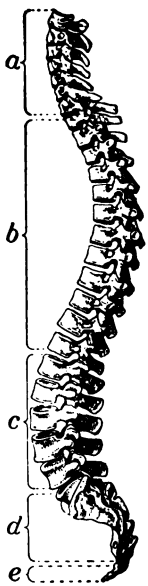
**What is the spinal cord and where is it located?** Next in importance to the brain is the *spinal cord*, a mass of soft tissue located in the backbone. The backbone, known also as the *spinal column* or simply as the *spine*, consists of a series of bones placed one above the other. Near the center of each bone is an opening, so placed as to form a continuous canal throughout the length of the column. This canal contains the spinal cord.

Each of the thirty-three separate bones in the spinal column is called a *vertebra*. The continuous canal formed by the cavities in the *vertebrae* is not entirely circular, but more nearly of a triangular shape, especially toward the upper end of the spine.

The top bone of the spine is called the *atlas*, after the mythological giant, Atlas, who was said to bear the world on his shoulders. The

skull rests on this bone as the round globe was said to rest on the shoulders of Atlas.

The second bone from the top provides a movable joint on which the head may be turned from side to side, and for this reason it is known as the *axis*.




*Spinal column from the left side*

*a*, cervical; *b*, thoracic; *c*, lumbar; *d*, sacral; *e*, coccygeal

The other vertebrae next in order are numbered third, fourth, fifth, sixth, and so on.

The upper part of the spinal column is called *cervical* (neck), the middle part *dorsal* (back), and the lower part *lumbar* (loins).

The vertebrae are joined together by elastic bands of tissue, called *ligaments*, in such a way that the spinal column may be bent from side to side, or forward and backward, without permitting the bones to move out of place. If one bone is displaced or injured so that the form of the central canal is changed or interrupted in any way, the spinal cord, the delicate nerve substance in the interior of the canal, would be injured or compressed. If this should happen, all parts of the body supplied by nerves having their origin in the spinal cord below the point of injury would be paralyzed.

There are two kinds of *paralysis* from which we may suffer. Paralysis may be caused by an injury to the brain, or by an injury to the spinal cord. In an injury to one side of the brain all of the opposite side of the body is paralyzed. But in an injury to the spinal cord both sides of the body below the point of injury are paralyzed. Thus in a case of paralysis any one who knows these facts can determine whether the trouble is due to an injury to the brain or to the spinal cord.

*An improper sitting position*

**What is infantile paralysis?** The disease known as infantile paralysis is the result of an infection of the spinal cord by bacteria, causing paralysis. It attacks chiefly infants and growing children, though occasionally grown people fall victims to it. How sufferers become infected with the bacteria is not known and no remedy has yet been discovered. The disease is often fatal, and, even if the victim recovers, he may continue to suffer from partial paralysis.

**What is meant by curvature of the spine?** The

*Improper position of the body when standing*

backbone or spine in a normal, healthy individual is curved when viewed from the side. But it is straight when viewed from the back or from the front. Sometimes there is a sharp, abnormal bend in the spine. Such deformity is known as *curvature of the spine*. It is often caused by habits of holding the body improperly when sitting or standing. People who are seated when at work often have a slight curvature to the left, caused by the fact that the right side is used more frequently than the left.

*Improper position of the body when walking*

Most of the diseases of the spinal cord begin with an injury, received very often in play or in the course of violent exercise. Some children injured in this way may recover entirely, while in other children the injury may cause the development of tuberculosis in the part of the spine that was affected. The result is permanent deformity and very often early death. Any injury to

the spine should at once receive the careful attention of a competent physician. It is too serious a matter to overlook. Often grave deformities that cause lifelong suffering may be prevented by prompt attention to such an injury.

Children should be cautioned against jumping

*A game of football*

from a great height down to a hard surface. The shock often causes an injury to the spine. Injury to the spine is also liable to occur in violent play, as in wrestling or in football playing. Football playing cannot be commended as an exercise for young children and is dangerous even for older persons. For young people such sports as baseball, tennis, running games, and swimming are greatly to be preferred to football.

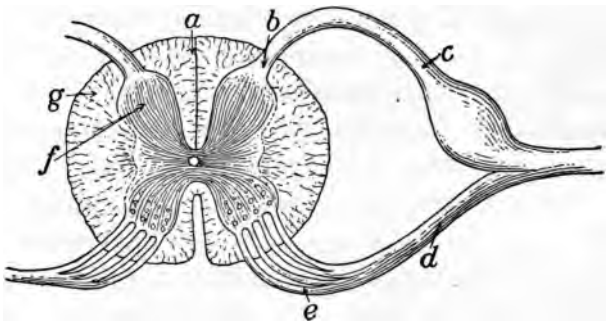
**What are the nature and function of the spinal cord?** The spinal cord is made up of long,

thread-like nerve fibers passing toward or away from the brain, and of nerve cells which send out more fibers or branches in every direction. All are bound together by connective tissue. The white appearance of the outside of the spinal cord is due to the presence of these fibers. The grayish appearance of the central part of the cord, as seen when one cuts across the cord, is due to the presence of cells. The front half of the cord controls physical movements; the back half carries to the brain impulses coming from special sense organs.

The spinal cord may be thought of as a continuation of the brain. While the brain is believed to have charge of our thinking processes and sensations, the spinal cord is thought to be that part of the same system which has charge of our muscular movements and sensations. When we are reading or studying, we are said to be cultivating our brains; when we acquire skill at play, or manual skill in such occupations as wood or iron working, or in playing upon a musical instrument, we are supposed to be educating the spinal cord. That scheme of development is best which includes the education of both the brain and the spine, so that we may become skilled in play, in work, and in exercise, and at the same time acquire knowledge.

## THE NERVES

**What are the nerves?** The nerves are fibers connecting the brain and the spinal cord with




*Section through spinal cord showing nerves*

*a*, spinal cord; *b*, emerging posterior root; *c*, sensory nerve; *d*, motor nerve; *e*, emerging anterior nerve; *f*, gray matter; *g*, white matter

every part of the body. They have the property of transmitting sensations of pleasure or of pain. They also control all muscular movements.

As the nerves approach the surface of the body they become finer and branch out into numerous thread-like fibers. These are so numerous that it is difficult to prick the skin with a fine needle without touching a nerve and feeling a sensation of pain. This sensation of pain is supposed to be carried along the nerve filaments to the spinal cord in a way that is not well understood. The sensation passes on through the spinal cord to the brain, where it is

registered as if it were a telegraphic message received at the end of a wire. Then another wave is sent back through the spinal cord and the nerve that controls the movements of the muscles.

When your finger touches an object hot enough to burn, you quickly though not instantly receive a sensation of pain. This is immediately followed by a sudden muscular movement which withdraws your finger from the hot surface. But this does not happen in time to avoid a burn. If the transmission of the sensation through the nerve and the reply to the message had been instantaneous your finger would have been withdrawn before it was burned. This simple experience aptly illustrates the phenomenon of the nerve functions.

**Can the speed with which messages are sent through the nerves be measured?** The speed with which nerve force travels along the nerves can be measured, though not with absolute exactness.

It has been estimated that the velocity of the nerve sensation in the adult human being is about 30.5 to 33 yards per second. The rate of transmission of sensation in infants is much slower than this, and in some animals the rate of transmission is even slower than in infants. In the lobster it has been discovered to be about six and a half yards per second; in fish the rate

is less than one fifth of a yard per second. But these figures are only approximate. All we can say definitely is that the movement in the nerve fiber, or the rate at which a sensation is carried along the nerve, is many thousands of times less rapid than the rate of transmission of a wave of electricity through a copper wire.

**What is the function of the nerves?** The nerves, as we have learned, have two distinct functions. One is to carry sensations of all kinds—heat, cold, pain, pleasure—to the nerve centers; the other, to carry an impulse from the nerve centers to produce muscular contraction or movement. The nerves are the means of communication between our nerve centers, the spinal cord and the brain, and the external world.

**What are voluntary and involuntary movements?** If you decide to reach your hand out for a book, the impulse to take the book originated in the brain center by a strange and mysterious force that we call the *will*. This impulse was carried along the nerves to produce a certain motion. You reach out your hand and take the book as determined by your will. Such a movement is called a *voluntary* movement.

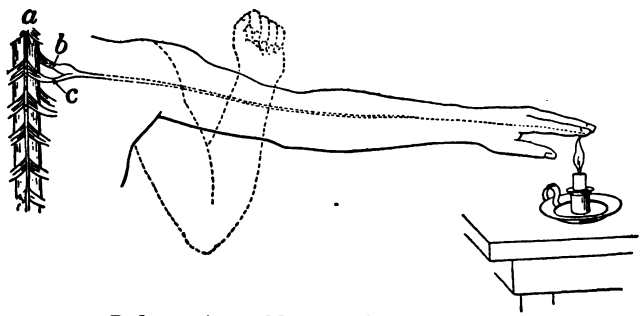
On the other hand, if your finger happens to touch a hot stove there is an entirely different process. A message is sent from your finger to the receiving office in your brain that your

finger is burning. Immediately a message is sent back to the muscle controlling your arm and hand to withdraw your finger from the stove. Such a movement is called *involuntary*. No person whose hand by chance comes in contact with a surface hot enough to burn it, can control this movement. It is true that by the exercise of your will you can deliberately place your hand on a burning surface and hold it there; that is, if your will is strong enough. But such an action is voluntary, while the action described is involuntary or reflex.

The beating of your heart is evidently a motion caused by nerve control. But the impulses which cause this motion are produced without your control, and the motion that results cannot be stopped by mere force of will. The movement of the diaphragm in breathing, by means of which the air is taken into and sent out of the lungs, is also involuntary. It is true that by exercising your will you can hold your breath for a certain length of time. There may be instances of persons who have held their breath long enough to cause death, but this is not possible for the ordinary person.

There is a distinct difference between the function of the nerves in carrying a sensation and in carrying an impulse for muscular movement. In other words, one kind of mechanism

is required for conveying a sensation and another kind for carrying an impulse to move a muscle. Separate wires—that is, separate nerve filaments—are provided which are connected with the spinal cord in different ways and at different places. The nerve filaments carrying sensations to the brain are called *sensory* nerves;




*Reflex action. Message of a sensory nerve*
*a*, spinal cord; *b*, sensory nerve; *c*, motor nerve

those transmitting an impulse from the brain to the muscles are called *motor* nerves.

The sensory-nerve filaments and the motor-nerve filaments are usually present side by side in all parts of the body wherever sensations are produced and movements required. But widely separate filaments may take part in connected sensory and motor processes. For instance, the sensation of burning the tip of the finger is transmitted by the very few sensory nerves affected by the burn. But the impulse to act is sent through all the motor nerves leading

to the muscles of the arm and the hand and the finger. Thus, while the sensation of pain is transmitted by a very few nerves, the effort to escape the danger or pain comes back by hundreds of nerves, some of them widely separated.

The action of widely separated sensory and motor nerves may be illustrated in another way. The nerves of the eye are spread over a membrane at the back of the eye. When you see a person or object the sensation of sight is transmitted along the sensory nerves of the eye. In answer to that sensation, either you may start in the direction of the person or object or you may turn and run away from it. In either case the motor nerves in nearly all the muscles of the body are active as a result of the sensation sent to the brain along the nerve of sight.

The nerves branch out from the brain to all parts of the body in much the same way as the arteries branch out from the heart, and come back from all parts of the body in much the same way as do the veins.

The nerve system is very intricate. But the general idea of its structure and functions that has been given is sufficient for our purposes. There are some things about it that it would be impossible to explain. The whole action of the nervous system is one of the great problems that science has not yet been able to

solve. We know where the nerves are, we know their functions, but by what means and by what power they perform them yet remain unrevealed.

There are certain special nerves, with certain special functions, called senses, which will be described in the following chapter.

### QUESTIONS TO HELP THE PUPIL

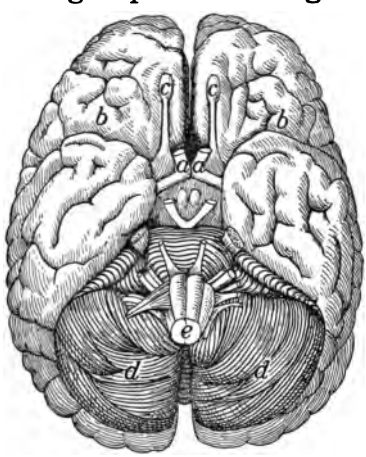
1. May injury to the spine cause paralysis? why? 2. How can you tell in a case of paralysis whether the brain or the spine is injured? 3. What causes infantile paralysis? Has a remedy been discovered? 4. What is curvature of the spine? How is it caused? 5. What disease sometimes develops when the spine is injured? 6. What kind of play should children be cautioned against? 7. What games are to be preferred to football playing?

8. Describe the appearance of the brain. 9. Where is it and how is it protected? 10. How is the skull formed? 11. Are the bones of the head in children firmly united? 12. What is the varying size of the brain in different persons thought to indicate? Is this always true? 13. What is the use of the brain? 14. Of how many parts does it consist? 15. Where is the spinal cord located? 16. Describe the spinal column, telling of its structure and naming its parts. 17. What activities are thought to be controlled by the spinal cord? 18. What is the work of the nerves? 19. Is it known how the nerves carry the sensation to the spine and the brain? 20. Tell what happens in the nerves when your finger touches an object hot enough to burn. 21. Are sensations transmitted as rapidly through the nerves in children as in grown persons? in animals? 22. How does the speed compare with that of electricity through a copper wire? 23. Define and describe a voluntary movement; an involuntary movement. 24. Name some involuntary or automatic movements. 25. What are sensory nerves? motor nerves? 26. May widely separate nerves take part in a sensory and motor process? Give an illustration.

# VII. A Study of the Senses

## THE SENSE OF SIGHT

**What is the optic nerve?** The optic nerve, or the nerve that makes it possible for us to see, is one of the most important of the special nerves. The eye, the organ of vision, is one of the wonders of the human body. It is shaped much like a big marble, and is filled with materials that permit light to pass through as light passes through a window pane. You have seen how a magnifying glass seems to enlarge an object seen through it. Such a glass is called a *lens*. The eye is provided with a lens made of a transparent substance held in a transparent membrane. This lens serves to concentrate the rays of light on a black membrane, called the *retina*, at the back of the eye.




*Under surface of brain showing the optic nerve*

*a,a*, optic nerve; *b,b*, cerebrum; *c,c*, olfactory nerve bulbs; *d,d*, cerebellum; *e*, spinal cord

In the retina are distributed the nerves of vision. The sensations produced on these nerves in the

retina by the rays of light that pass through the lens of the eye are carried along the nerve called

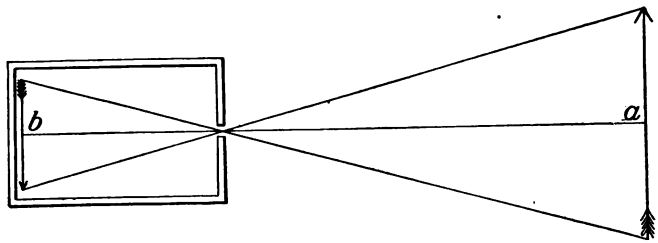



*Diagram of a camera showing inverted image*

the *optic* nerve to that part of the brain to which the nerve is connected. There are registered the images produced on the retina.

If you look closely at the eye of your friend you will see in it the image of yourself. But that image is merely the reflection of yourself as from a mirror. The image your friend receives of you lies on the black curtain or retina at the back of the eye. But if you could see the retina you would see nothing but a black surface. There is no difference in principle between the way the eye is made and the way a camera is made. Both have a lens in front through which the light is concentrated on a black sensitive curtain at the back.

The image of an object, registered in the brain, is the same for all normal eyes. Looking at a picture you will see just what your neighbor sees, unless your eye or your neighbor's is defective.

**What are the chief parts of the eye?** The eye is an almost perfectly round ball from three fourths of an inch to an inch in diameter, so placed in a depression in the bones of the face and skull as to leave exposed only a portion of its surface.

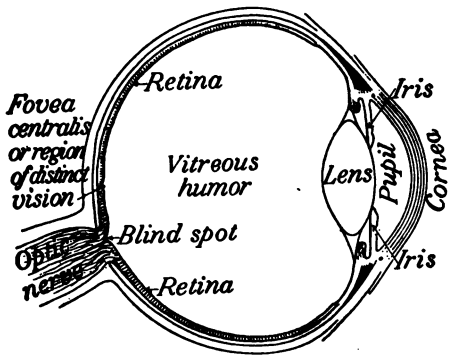


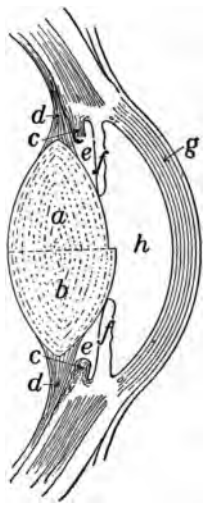
*Diagram of the eye*

The white outer coating of the eyeball, a portion of which is visible between the eyelids, is known as the *sclerotic* coat, from a Greek word meaning "hard." This coat is *opaque*, that is, light cannot pass through it, except in the portion over the round colored spot in the front part of the eye. That portion of the outer coat is called the *cornea*. The cornea projects from the surface of the eyeball so that it looks as though it were a part of a smaller sphere lying within and slightly projecting from a larger sphere.

The eye is filled with a transparent jelly-like substance called *vitreous humor*. Vitreous means "resembling glass." The vitreous substance in the eye, however, resembles glass only in its quality of transparency. Toward the

front, just behind the cornea, is a transparent semi-solid substance known as the *crystalline* lens. It is made up of various layers or cells, which may be compared to the layers of an onion so far as structure is concerned. It is through this lens that the rays of light pass to the sensitive inside coating of the eye, which has already been spoken of as the retina.

The retina is a black membrane, over which the numberless filaments of the nerve of vision, the optic nerve, are distributed.




*Section of the eye showing lens*

*a*, lens adjusted for far objects; *b*, lens adjusted for near objects; *c*, *c*, ciliary process; *d*, *d*, suspensory ligament; *e*, *e*, posterior chamber; *f*, *f*, iris; *g*, cornea; *h*, anterior chamber

Back of the cornea and in front of the lens is a colored curtain called the *iris*. In the center of the iris is a circular opening the size of which is adjustable according to the intensity of the light. This opening is called the *pupil*. When the light is strong the iris contracts so that the opening is very small; in the dark the iris expands so that the opening is very large. The iris corresponds to the diaphragm of a camera. If the light is very intense the diaphragm of the camera is set so that the hole through which the light enters is very small. If the light is

less intense the hole in the diaphragm of the camera is made larger. In the iris the adjustment of the opening is accomplished by means of small muscles which act automatically. The opening in the iris, whether large or small, always remains circular.

**What causes the color of the eye?** The color of the eye is due to the coloring pigment in this movable iris. In all eyes the pupil appears to be nothing but a black spot. What you see there is probably a part of the retina. But what we call the "color" of the eye is determined by the color of the iris. The color of the iris is never black, but varies from deep brown through all the different shades to light gray or blue.

**Are there other lenses in the eye besides the crystalline lens?** The fluid in the front part of the eye, between the crystalline lens and the cornea, forms another lens. This fluid is called *aqueous*, meaning watery, because in its density it does not differ largely from water. The vitreous humor, which we have learned fills the greater part of the cavity of the eye behind the crystalline lens, also forms a lens.

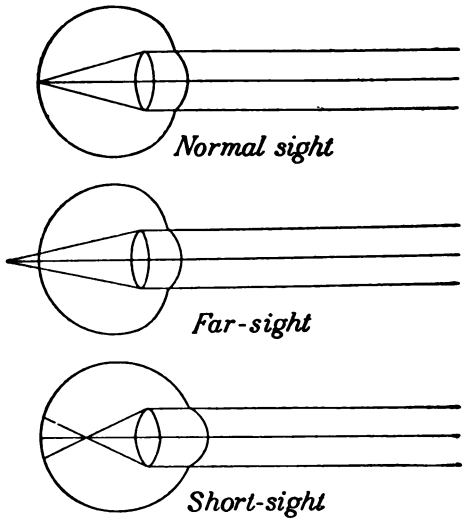
**What is blindness?** Blindness is the incapability of the optic nerve to receive or transmit sensations of light. It may sometimes be the result of some defect in the optic nerve or it may be caused

by some defect in the eye itself. If there is a defect in the lens, light cannot be transmitted to or concentrated properly on the retina. If there is a defect in the retina, the nerves cannot receive the impression or transmit it to the optic nerve. On the other hand the brain cells that receive the impression may be diseased. Thus blindness may result from defects in the make-up of the organ itself, from defects in the transmitting apparatus of the optic nerve, or from defective brain cells. When we say that an eye is "put out," as the saying is, it does not necessarily mean that the eye is removed from its socket but that it is so injured that it no longer perceives sensations of light. The destruction of the lenses of the eye by accident, or the hardening of these lenses because of old age or some other reason, may result in blindness.

**What is the disease known as cataract?** The word "cataract" usually makes us think of water falling over a steep cliff. But when we use this word in speaking of the eye we mean the hardening and whitening of the crystalline lens.

When this lens becomes hardened and whitened so the light can no longer penetrate to the retina, it may be removed and the remaining lenses used in its place. The vision will be restored, but it will not be so perfect as before.

**What is nearsightedness?** The crystalline lens of the eye may be so formed that the rays of light from an object are brought together at a point that falls short of the retina, that is, somewhere between the lens and the retina. In some persons also the eyeball may be too long from front to back. In such cases the rays of light from objects come together at a point that also falls short of the retina. In both these cases the person is said to be near-sighted.



*Diagrams of eye showing normal, far, and short sight*

**What is farsightedness?** Farsightedness results when the lens is so formed that it does not bring the rays of light to a point quickly enough or when the eyeball is short from front to back. A farsighted person can see better if the object is at a greater distance. In perfectly normal eyes the lenses are so adjusted that the person

can read print very well at a normal distance of fifteen or twenty inches and also can see objects at a distance of one hundred feet, or half a mile, or mountains ten miles or even farther.

**How may nearsightedness and farsightedness be corrected?** With a knowledge of the causes of nearsightedness and farsightedness, the man who has the skill can so grind lenses of glass as to correct the faults in the natural lenses of the eye. For nearsightedness a lens of one form and thickness is ground, and for farsightedness, a lens of another form and thickness. In this way opticians are able to correct imperfect vision due to faults in the structure of the eye.

**What is astigmatism?** In some eyes the cornea may not be curved correctly; that is, instead of forming an evenly curved surface there may be flat places on it. Such a defect may also be found in the crystalline lens. The rays of light that pass through such an uneven surface cannot come together at the same point on the retina. The result is that some parts of the image are clear and other parts blurred. This trouble is called *astigmatism*.

**How may astigmatism be corrected?** In cases of astigmatism the skilled optician provides glasses in which the form of the lens corrects the defects in the cornea or the lens and causes the rays of light to come together to a point.

**What is meant by the term "cross-eyed"?** The movement of the eyes in their sockets is controlled by a number of small muscles. The eye can be moved to the right or left, up or down, or in a circle, in order that we may look at objects in different places without turning our heads. In normal eyes the movements of the muscles are coördinated; that is, they work so as to move both eyes at the same time in exactly the same way. You cannot move one eye without moving the other, though you can move one finger without moving another.

Eyes are said to be crossed when the lines of vision are not parallel, that is, when they do not look in the same direction at the same time. They may either look toward each other, so that the lines of vision cross, or they may be turned outward, though such cases are rare.

**How may cross-eye be corrected?** Cross-eye cannot be corrected by any kind of mechanical contrivance. If there is only a slight crossing it may be helped by a skillful adjustment of eye glasses. In serious cases, there are only two plans to follow—either to leave the task to nature, which sometimes corrects this trouble, or to secure the services of a surgeon. An eye is turned too far in one direction or the other because one set of muscles is stronger than the other. For instance, the muscle that pulls the

eye toward the nose must not be stronger or weaker than the muscle that pulls the eye in the opposite direction. Thus both eyes can look straight forward or they can turn an equal distance to the left or to the right. If the muscle that pulls the eye toward the nose should become stronger than the muscle that pulls outward, the eye would be turned in. In such cases the skillful surgeon can cut some of the filaments of the muscle that is too strong.

Crossing of eyes is often due to eye strain which arises from the intense effort to compensate defects in the seeing apparatus. In such cases glasses correcting the defects in the lens of the eye will also often correct the crossing.

**What is meant by "sore eyes"?** In addition to the disorders to which attention has already been called, the eye may be affected by various kinds of inflammation which attack the membranes surrounding it. These inflammations are often of an infectious character. The eye inflamed by overuse may cause the blood vessels of the eye to carry to it a larger amount of blood than is needed. These unnecessary particles of blood sometimes remain in the capillaries, thus producing what we call "bloodshot" eyes. Overstraining, or using the eye in too brilliant a light, will cause similar troubles.

When reading, one should never face the

light. It should come obliquely from behind, over one or the other shoulder of the reader as is most convenient. Using the eyes in a very bright white light may be injurious. The green light produced from tubes filled with mercury vapor or by the use of green shades is less harmful to the eyes than the white or brilliant light of the electric arc or incandescent lamp, or of the gas jet surrounded with a mantel.

Abraham Lincoln used the light from a burning log in the fireplace. The light given off by such a flame is yellowish and is not very brilliant, so probably it did not hurt his eyes. We do not read by that kind of light now, and we are not so careful as we should be to shade our lights or to sit in such a position as to avoid eye strain.

**Has the eye any relation to health?** The eye is very important in its relation to health. Many forms of headache are due to defects in the eye. When these defects are remedied by the use of glasses ground correctly, the headache disappears and the general health is improved.

**Has light any relation to health?** Not only is light necessary in order that our eyes may see, but light is also of the highest importance to good health. Without light, normal growth is impossible. If you put a potato in moist earth in a dark cellar it will sprout, but the plant will never reach mature growth and will have no

color. If you keep a child in a dark room he may grow, but he will be thin, white, and imperfectly developed.

But as a rule the beginning of all growth requires an absence of light. A seed will start to grow much more readily when covered with earth or if it is kept in the dark than if exposed to the light of the sun. All bacteria are vegetables of a primitive character, and hence, like the seed of a vegetable, which is its primitive stage, the germs grow best in the dark. So light is of the highest importance to us, not only because it helps us to see and to grow, but also because of its ability to kill germs that threaten our health. There is no better *germicide*, or germ killer, than bright sunlight.

Light is as necessary to our existence as heat. Fortunately, one usually accompanies the other. The sun is the origin, so far as our world is concerned, of both light and heat. Light is indispensable to our health, and to it we owe most of the joys of life.

**What is the value of light in convalescence?** The convalescent—the person who is on the way from sickness to health—should be kept as much as possible in the sunlight. Unfortunately there are some diseases in which light is injurious, as, for instance, in diseases of the eye or diseases which affect the eye. Measles makes

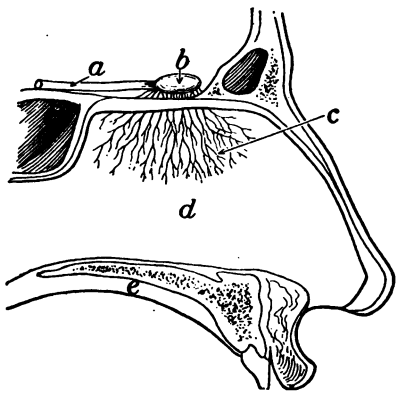
the eye sensitive, and the boy or girl suffering from this disease must be kept in the dark. The person suffering from inflammation of the membranes of the eye must also be kept in the dark. But if a person has tuberculosis, or is recovering from some ordinary illness, he should remain constantly in a well-lighted as well as a well-ventilated place.

Light is very effective in preventing the loss of hair. The sun's rays tend to kill germs that destroy the hair. If we go bareheaded as much as we can, and let the sun shine on our heads, there will be fewer bald heads in the future than there are at the present day. Tight hats cut off the blood supply from the scalp and thus promote baldness.

## THE SENSE OF SMELL

**What is the olfactory nerve?** The sense of smell is communicated to the brain through two nerves, the filaments of which are distributed in the shape of a fan principally on both sides of the membrane separating the nostrils. These nerves are called the *olfactory* nerves. They connect directly with two bulbs in the base of the brain, called the olfactory bulbs, and these in turn are connected with that particular part of the brain which seems to preside over the sense of smell.

**How do the nerves carry the sensation of smell?** Just how the olfactory nerves receive and transmit the sensation of smell is not understood any better than how any nerve carries any kind of sensation. All we know is that it is their function to do so. Substances that have an odor and therefore affect the sense of smell are believed to give off very minute particles that carry the odor. These particles of matter strike against the filaments of the nerves in the nasal passages and excite them in such a way as to produce a certain sensation. This sensation is transmitted through the olfactory nerves to the olfactory bulbs and then to the brain. The sensation may be one of two general kinds, the agreeable or the disagreeable. The odors that produce an agreeable sensation do not excite the nerve filaments in the same way as do those that produce a disagreeable sensation.




*Section of nose showing olfactory nerve*
*a*, olfactory tract; *b*, olfactory bulb; *c*, olfactory nerves; *d*, nasal cavity; *e*, roof of mouth

**Does the sense of smell in various animals differ in keenness?** Very much so. Some animals

have so keen a sense of smell that it is almost unbelievable. By means of this wonderfully

*Bloodhounds scenting the trail*

developed sense some dogs are able to trace the course which an animal or a man has taken. A dog and a human being are at almost opposite extremes in regard to the sense of smell. In man it is at a decidedly low stage of development, while in the dog it is very highly developed. The hound can follow a trail swiftly and unerringly, so quickly are his olfactory nerves affected by the slightest odor. Bloodhounds can distinguish the odor of one individual from that of another, and can thus track a certain person on trails over which many others have passed. The keenness of the sense of smell in such cases seems almost beyond comprehension.

**Why do colds diminish the keenness of scent?** It is easy to understand how a cold affecting the nasal passages can diminish the sense of smell and even stop it entirely. The olfactory nerve filaments are placed in the mucous membrane of the nose in such a way that the minute particles carrying the odor may come in contact with them. A cold in the nose causes inflammation, a temporary thickening of the mucous membrane, and the excretion of large quantities of mucus which cover the membrane and thus prevent odors from affecting the nerve filaments. When the inflammation reaches a certain degree, the sense of smell is for a time entirely lost.

**Are there differences in the keenness of scent among different persons?** There is just as much difference in the development of the sense of smell in different persons as there is in the development of other senses. In some people the sense of smell is very keen. There are many persons who cultivate it, for it is as capable of cultivation as any other sense. In those whose profession it is to distinguish between various objects by the sense of smell, this sense becomes very highly developed. The expert distinguishes the various grades of teas, coffees, alcoholic beverages, and other products largely by the sense of smell. Some persons also are naturally endowed with a keener sense of smell

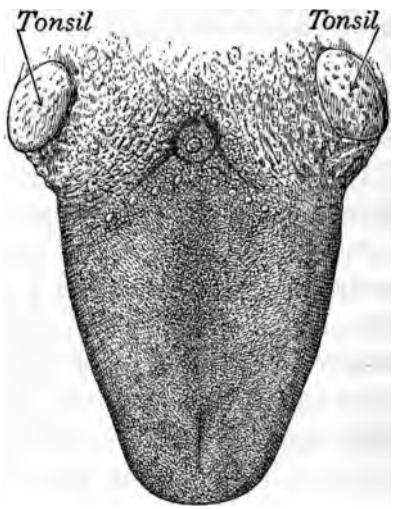
than others, and so are much more capable of telling the difference between odors.

**Does the sense of smell have any relation to health?** The sense of smell has important relations to health. Most foods have an agreeable odor when they are fresh and suitable for eating. If they are decayed or unwholesome the agreeable odor is changed to a disagreeable one. Thus the sense of smell tells us what is good for us to eat and what is bad. Though the odor of a fresh egg is not particularly agreeable, still it is not offensive. But if the egg is bad our sense of smell tells us immediately that it is unfit for food. In the same way harmful gases mingled with the atmosphere are revealed by their odor and we are thus placed on our guard. Thus we see that the sense of smell aids us in many important ways in keeping our health.

**What is the relation of the sense of smell to the flavor of our foods and drinks?** The term "flavor" is often used incorrectly. Flavor is not taste alone, nor is it odor alone. The flavor of a food is its taste and smell combined. Sugar, for instance, tastes very sweet, but as it does not produce a sense of smell, sugar has no flavor. In order to have a flavor a substance must have the properties which excite, at the same time, both the nerve of taste and the nerve of smell.

## THE SENSE OF TASTE

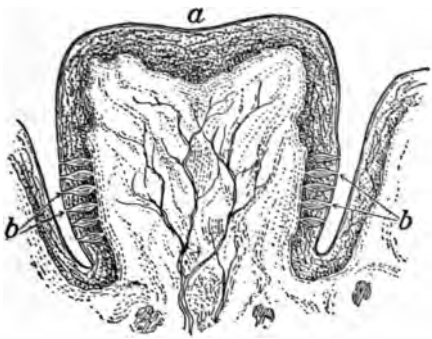
**What is the nerve of taste?** Just as the thought of an odor brings the thought of the nose to our minds, so the idea of taste brings the thought of the tongue. The tongue has more than one function. It is especially useful in speaking. Without the tongue, the sounds made by means of the vocal cords would not be *articulate;* that is, they could not be formed into definite sounds and words. Another important function of the tongue is to assist in chewing and in carrying food into the back part of the mouth, where it is seized by the muscles of the throat and carried into the esophagus. All these functions of the tongue are important and useful. In our present discussion we shall regard the tongue particularly as the organ of taste.



*The tongue*

The tongue is covered with numerous small projections called *papillae*, which form a part

of the mucous membrane covering the tongue. The papillae, when magnified, appear to be projections of considerable size, around each of which is a depression or furrow. The nerve of taste, called the *gustatory* nerve, divides into minute threads or filaments that pass into the papillae and emerge in the depressions around the papillae in what are called *taste buds*. The nerve of taste does not appear to communicate directly with the brain, but reaches it in connection with other nerves, and especially with the one known as the fifth nerve. That certain portions of the brain have charge almost entirely of the sense of taste is evident from the fact that injuries to certain connections of the fifth nerve in the brain destroy or at least cause injury to the sense of taste.



*Section of papilla valata of the human tongue, showing taste buds*
*a*, papilla; *b*, *b*, taste buds

**How many kinds of taste do we possess?** The sensations produced in the nerve of smell have been classified broadly as agreeable and disagreeable. A more detailed classification can

be made of the various sensations of taste. The sense of sweetness is usually a highly developed sensation. There is also a distinct sensation of bitterness. But the sensation we call sour, or acid, is entirely different from these two. Probably a sour or acid taste is more nearly the opposite of a sweet taste than the taste we call bitter. Forming another distinct class of taste sensations are those caused by common salt and similar substances. This is called the saline or salt taste. As we have already learned, the sense of taste, together with the sense of smell, has the function of perceiving flavor.

These separate sensations may be regarded as the principal kinds of taste sensations. But when mingled they produce numberless variations and combinations in which all these kinds take part.

**What is the theory of transmission of the sense of taste?** We find that the transmission to the brain of all our knowledge of the world around us depends on actual physical contact of substances with the various nerves. This is also true of the transmission of taste. The substances which produce the sensation of taste must come into direct contact with the nerve filaments distributed at or near the surface of the mucous membrane in the depressions around

the papillae. We cannot conceive of any other way in which the sensation of taste can be produced.

It is probable that the nerves of taste in various parts of the tongue have different degrees of sensibility, and even perceive different kinds of taste according to their location. The expert taster can distinguish the difference between the taste of a substance when held near the tip of the tongue and the taste of the same substance when held farther back toward the throat. It is reasonable to suppose that the *anterior* (front) filaments are less delicate than the *posterior* (back) filaments, since they come into contact with the food when it is in a more or less solid state. It may be that the differences in the taste sense in different parts of the tongue are not because of any particular differences in the nerves, but because some taste nerves are less sensitive than others. It is generally believed that a bitter taste is most readily perceived near the back of the tongue. It is even claimed that at the tip of the tongue a bitter taste cannot be perceived at all.

**In what condition must a material be in order to produce the sensation of taste?** Substances do not affect the sense of taste unless they are wholly or partly in a state of solution. If the surface of the tongue is perfectly dry and the

substance placed on it is perfectly dry, no sensation of taste is produced. But if the substance is either in solution or else so finely cut up that it has the properties of a liquid, the nerve of taste is immediately affected and the sensation is transmitted to the brain.

The taste of a hard substance develops quite rapidly with chewing, and a much stronger sensation of taste is produced than when the food is in coarse fragments or partly dissolved. Thus we are able to judge by the sense of taste when our food has been chewed well enough and is ready to be swallowed.

**What is the effect of temperature on the sensation of taste?** If the temperature of food substances is widely different from the normal temperature of the mouth, the sense of taste may be very seriously affected. If a substance is extremely cold it produces a sensation of cold, which itself tends to deaden the sense of taste. On the other hand, if a substance is very hot it produces such a painful sensation as to check all sensation of taste. Thus if we put an exceedingly cold substance or an exceedingly hot substance into our mouths we lose the sensation of taste. It may be that the nerve of taste is active, but the sensation of taste is so obscured b[illegible] [illegible]nger sensation of heat or cold that [illegible] to lose all trace of taste.

We would expect the activity of the nerve of taste to be at its best when the temperature of the substance is the same as the temperature of the mouth itself, or about ninety-eight and a half degrees. As a matter of fact, however, experience has shown that a somewhat lower temperature is better. We can best distinguish slight differences in taste at a temperature of from sixty-five to seventy-five degrees.

**Has the sense of taste any relation to good health?** The sense of taste has a very important relation to health. It is the taste of a substance that to a great extent causes the secretion of the fluids which digest the food. A good taste tends to increase the activity of the glands that secrete these fluids. A bad or objectionable taste will produce entirely the opposite effect. So it is evident that the sense of taste bears a very important relation to health.

**What is the effect of temperature on the wholesomeness of foods?** The temperature of the food we eat has also an influence on health. Those who have trained the sense of taste and the sense of smell to perceive very delicate flavors, are extremely particular in regard to the temperature of their food and drink. In tasting red wine an expert taster requires the temperature of the wine to be about seventy-five degrees. On the other hand, most persons

who have no knowledge of the nature of the sense of taste desire their foods served at a very low temperature. This is true especially in the United States, where most families, even those in moderate circumstances, are able to keep ice during the summer.

There is a perfect mania, particularly in summer, for ice-cold drinks — water, lemonade, buttermilk, and other beverages. We also have a great desire for ices and frozen dainties of all kinds and of all descriptions. But the laws of nature are very seriously abused when we take foods at so low a temperature. We are equally fond, especially in winter, of certain very hot drinks, thus going to the other extreme. In both cases the sense of taste is impaired by the extreme temperatures, which is more or less injurious to health.

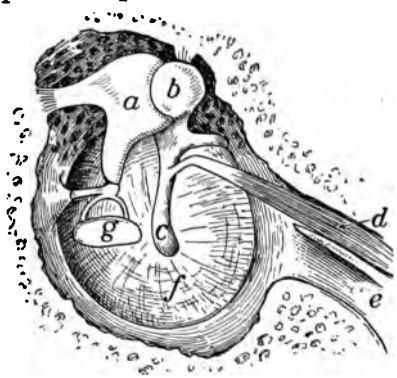
The lesson to be learned is that we should not eat foods above or below certain temperatures—cold foods not below fifty degrees, and warm foods not much above the temperature of the body. If we observe these precautions we can perhaps save ourselves from serious harm.

We should avoid the copious use of ice-cold drinks during the hot days of summer. Water is perfectly palatable at a temperature of from fifty to sixty degrees, while ice water has

practically no taste whatever. Thus when we go to extremes in temperature in our daily diet we not only lose a great deal of the pleasure of eating, but we injure our health besides.

### THE SENSE OF HEARING

**What is the auditory nerve?** The *auditory* or hearing nerve is another path over which the knowledge of the outer world reaches the brain. The external ear has little to do with the sense of hearing. It merely receives the sound waves and directs them inward. The real ear is inside the head in a very hard bone. It has two important parts called the *middle* and *inner ears*. The passage leading to the middle ear is closed a short distance in by a membrane which may be compared to the head of a drum. This membrane, stretched tight across the opening, is called the *tympanum*, a Latin word meaning "drum." Back of the tympanum is the middle ear.




*The drum and bones of the ear*
*a*, incus (anvil); *b*, malleus (hammer); *c*, handle of malleus; *d*, sensor tympani; *e*, Eustachian tube; *f*, tympanic membrane; *g*, stapes (stirrup)

The middle ear is connected with the throat and mouth by a tube, called after the name of its discoverer, the *Eustachian* tube. This tube has a double purpose. By means of it the middle ear is kept moistened and full of air. The pressure of air on the inside of the drum is thus kept the same as on the outside. Should the Eustachian tube become clogged, as sometimes happens in case of colds or sore throat, the air would be shut off from the middle ear. Then the pressure of air on the outside of the drum would push it inward and the hearing would be affected.

**How is the sensation of sound produced?** Whenever a word is spoken the movement of lips and vocal cords sets the air into vibration in every direction, very much as the ring-like waves of water are set into vibration when a pebble is thrown into a pond. Some of these air waves strike against the drum of the listener's ear, making it vibrate also. The vibrations of the drum cause the bones of the middle ear to vibrate, and then the membranes and liquids of the inner ear. Finally, in the inner ear, end organs of the auditory nerve pick up the vibrations and send them on through nerve fibers to the brain. When the vibrations reach the brain the listener hears sound. The same thing happens whenever *any* sound occurs. Something in

the air must set up a wave motion which travels in every direction. These waves strike every object within a certain radius and reach the ear drum of any person who happens to be within hearing distance. The air waves start a vibration in this membrane corresponding in character and strength to their character and strength.

**In what particular way is sound transmitted from the ear drum to the brain?** Immediately within the ear drum is a series of three small bones. The first touches the ear drum and rests on the second, and the second rests on the third. The third bone connects with what is called the *inner ear* where are located the nerves of hearing. It is through these three little bones that the sound is started on its journey to the brain. They are provided with muscle-like cords by means of which they can be tightened or loosened, in much the same way that a violin string is tightened or loosened by means of a peg. Thus the sensitiveness of the bones, that is, their power of transmitting sound, may be increased or diminished by the action of the muscles attached to them.

These cords adapt the apparatus of the ear to the special sound it is trying to transmit. The auditory nerve terminates in the inner ear in hair-like filaments or cells. These receive the vibrations transmitted by the small bones

in contact with the *tympanum*, or ear drum, and send them inward toward the brain. These numerous hair-like cells are arranged in quite regular rows and may be compared to the keys of an organ or a piano, though there are more than two rows. In fact, there is a very large number of these organ keys; it is estimated that there are from twelve to twenty thousand. Thus it is evident that the complexity of the ear organ is far greater than that of the church organ.

**What is a phonograph?** The word "phonograph" means sound writing. If you attach a feather to a membrane stretched like the head of a drum, and allow the point of the feather to rest on a piece of smoked paper or glass while you speak a series of words, and at the same time move the smoked plate, the feather will write in waving lines. This proves that the words you spoke caused a series of vibrations in the membrane. If instead of the feather you use a delicate needle with a sharp point capable of writing on wax, you have the basis of the phonograph.

In the phonograph you speak into a tube leading to the membrane. That membrane has a pen attached to it which rests upon a moving wax cylinder or plate. The waves of sound transmitted to the membrane cause the

pen to write a waving line in the wax corresponding to the strength and character of the sound of the words you speak. In much the same way the vibrations in the drum of the ear are recorded, not on smoked glass nor on wax but in the brain itself.

**What relation has the ear to health?** The power to distinguish sound is one of the important means we have of knowing what is going on around us. For this reason it is evident that the sense of sound is of great importance to our welfare. The sense of sound often warns us of physical danger, so that we are able to avoid accidents or injuries which otherwise would befall us.

The ear is subject to certain diseases more or less injurious to our general health. Back of the ear is a portion of the skull, called the *mastoid* bone, which is spongy in character. In certain disorders of the ear this bone sometimes becomes affected, causing great pain and danger. The ear itself, with its various organs, is often subject to strain or inflammation. This causes earache, a troublesome disease. The tube leading from the ear to the throat, called the Eustachian tube, may also become infected as the result of colds or inflammations, and may even become clogged, a most dangerous c dition.

The sense of hearing gives us many of the pleasures of life. The conversation of friends, the notes of beautiful music, the song of the birds in the trees, the chirp of the cricket, the sound of running waters, all are pleasing and give us a feeling of happiness and contentment. In this way the sense of hearing helps to keep us in good health by making us happy.

**Are we able to locate the sources of sound?** When we see an object we know exactly its location and can judge approximately its distance and its size. When we hear a sound we are not able to tell exactly where it came from. The source of a sound can to a certain extent be located, but with nothing like the accuracy with which a visible object can be located. People differ greatly in their ability to sense the source of sounds.

**How fast does sound travel?** In the air sound travels about 1,100 feet per second; in solid bodies it travels much faster. It was recorded that the cannonading at Fort Donelson on the 14th of February, 1862, could be heard nearly 200 miles away. Subsequent investigation showed that the sound had traveled through a layer of limestone. Sound may be carried much farther through solid bodies than through the air. You see the flash of the lightning some time before you hear the thunder.

## THE SENSE OF TOUCH

**What is meant by the sense of touch or feeling?** If we close our eyes and place our hands on an object, a distinct sensation is experienced. The nerves that transmit this sensation to our brains are the nerves of touch or feeling. The moment our hands come in contact with an object we can determine, without looking at it, whether it is hard or soft, rough or smooth, round or angular, and whether it is hot or cold. Thus it is clear that the sense of touch or feeling is a very complicated sense into which enter a great many factors.

Some of the things that can be determined by the sense of touch, can also be determined by the sense of sight. For instance, the shape of an object, and whether it is rough or smooth, can easily be determined by looking at it as well as by feeling it. On the other hand, there are certain characteristics of an object revealed by the sense of sight which the touch cannot reveal —for instance, the color.

Of all the senses, that of touch may be regarded as the most universal; that is, it gives us more information and of a more varied character than we can gain from any other set of nerves. But it cannot be regarded as the most desirable or pleasurable, though without doubt it is the most useful. We may lose the sense of

sight, of hearing, of taste, of smell, and still exist tolerably well, but should we lose also the sense of touch we should be utterly helpless. The case of Helen Keller is a remarkable instance of the possibility of obtaining a fine education through the sense of touch alone. Through illness she lost the senses of sight and hearing at a very early age, yet she has become a cultured and highly educated woman.

**How is the sense of touch or feeling exerted?** The nerves which carry the sensation of touch are located mostly in the skin. The skin has already been described as a very useful and necessary covering of the body. It can now also be described as the chief organ of touch. The skin is by no means the only part of the body that has nerves of touch. Such nerves are found also in the tongue and in the muscles and to a certain extent in the internal organs of the body, though in the latter they are greatly modified.

The best authorities declare that the various functions of the sense of touch are not carried on by the same nerve filaments. In other words, the sensation by means of which we get the outlines of a body and determine whether it is rough or smooth is carried by one kind of nerve filament, while the sensations of cold, of heat, and of pain are each carried by other kinds of

nerve filaments. These filaments are probably continuous—that is, they pass in bundles from the brain through the spinal cord and radiate from the spinal cord to all parts of the body, where the bundles break up into the separate filaments.

The skin itself is not perfectly smooth, as one might suppose, but is covered with numerous small projections or papillae, particularly on the scalp and often on the arms and other parts of the body. These papillae carry hairs which may be regarded as the advance guards of the nerves of touch. Anything coming in contact with one of these fine hairs is likely to stimulate the sense of touch.

The principal purpose of hair is protection, but it also has the secondary property of exciting, or tending to excite, the nerves of touch.

The nerves of touch vary in abundance in different parts of the body. They are very numerous in the hands, the feet, and at the tip of the tongue. They are more sparsely distributed over the skin of the arms, the neck, the back, and other portions of the body. There are more of these sensory points in the fingers and the tongue than in any other part of the body.

The remarkable skill that can be developed

in the fingers results from the training or education of the nerve of touch. For instance, in such trades and professions as piano playing, billiard playing, watch making, or surgery, the sense of touch must be highly developed.

**Are the internal organs supplied with nerves of touch or feeling?** The nerves of feeling in the internal organs are few in comparison with the number in the skin. We do not have any pleasurable sensations in the internal organs. The nerves of feeling there mostly transmit feelings of pain. If there is anything wrong in the internal organs, the nerves send messages of pain to the nerve centers.

The brain is almost without nerves of sensation. Headaches are usually due to pain in the membranes of the brain. In the same way when the appendix becomes inflamed we have severe pain, but the pain is due largely to the membranes which surround the appendix.

In general we may say that the nerves of feeling are distributed through all parts of the body, but are especially abundant in the skin and the mucous membranes.

**What nerves convey the sensation of pain?** [illegible]st any nerve will convey a sensation of [illegible]. An extreme sensation of any kind be- [illegible]ıful. For instance, a very strong [illegible]se the olfactory nerve to convey

a painful sensation. A very strong light causes a sensation of pain in the eyes. But the feeling of pain, as generally understood, is conveyed by filaments of the nerve of touch or feeling. These filaments are perhaps the most numerous and abundant of all nerve filaments. It is, as we have said, difficult to prick the skin without touching a nerve conveying a sensation of pain. Just what form of vibration, or by what method of movement, the sensation of pain is communicated to the brain, no one knows.

Painful sensations are of two general kinds. Pressure or puncture of the skin produces one of the most common forms of pain. The sensation of cold is another kind of painful sensation. But the nerves that carry the sensation of cold are not so numerous as those that carry the sensation of other forms of pain.

**What nerves convey pleasurable sensations?** Agreeable odors and tastes are types of pleasurable sensations carried by the special nerves of the nose and the tongue. Agreeable music produces a pleasurable sensation carried by the nerves of the ear. Landscapes and pictures and forests and streams produce pleasurable sensations carried by the nerves of the eye. The nerves of touch in the skin also convey pleasurable sensations, due largely to a proper degree of warmth or gentleness of pressure on

the skin. It is very difficult to describe these sensations, but we need appeal only to our own experience for a further knowledge of them.

**What relation has the sense of touch to our health and welfare?** The sense of touch guards our health and comfort in many ways. The sensation of cold warns us against temperatures that would injure the tissues of the body and perhaps cause death. The sensation of heat likewise warns us from coming in contact with things hot enough to cause injury. The nerves of touch tell us the proper temperature in which it is comfortable to live. In the winter we seek a temperature warm enough to prevent discomfort from cold and yet not hot enough to threaten health.

The sense of touch warns us to avoid those things which experience teaches are nearly always harmful. It also leads us to seek those things that add to our comfort and welfare. Thus from every point of view the sense of touch is highly important in regard to our physical well-being.

**Are we always able correctly to locate sensations of pain?** Though we generally know where we have a feeling of pain, sometimes we cannot locate it correctly. The pain of a toothache sometimes seems to be not in the tooth really affected but in some other tooth. A pain in

the eye or in the back of the head may not really be localized there, as we suppose. The sensations of pain are reported to the brain, but are not always referred by it to the exact place where the trouble lies.

It is well known that years after persons have lost an arm they experience pains that are referred by the brain to the missing member. So a feeling of pain in a certain part of the body cannot always be regarded as a certain indication that the trouble will be found there.

But as a rule we have little doubt as to where the trouble really is. In the case of pain in the internal organs we are more likely to be misled than in the case of pain in any exterior parts where the skin is the organ of sensation.

**How can the delicacy of touch and feeling be increased?** The sensitiveness of the nerves of touch and feeling may be increased by constant and judicious use. Education in the ordinary sense of the word is the training we get from books and teachers in school; in other words, it is a cultivation of the brain. To increase the delicacy and sensitiveness of the nerves of touch by constant and judicious use may be regarded as part of the education of the spinal cord.

The skill which can be acquired by educatin
the nerve of touch is extraordina
listen to a master at the piano a

what he does with the slow and clumsy efforts of the beginner, we have a good illustration of the cultivation of the sense of touch. The skilled typist operates her machine swiftly and accurately without looking at the keyboard. This is true also of the skilled pianist. The billiard expert can make shots which to the unskilled player appear supernatural. The skilled surgeon can thrust his knife among the vital parts of the body, cutting out the offending organ, and saving life in a way that seems due to almost more than human achievement. Such manual skill, due largely to the delicacy of the sense of touch, is called *technique*.

*The skilled pianist plays without looking at the keyboard*

There is no form of labor that cannot be more efficiently performed after cultivating the [illegible]ense of touch. From this we learn the great [illegible]ce in our schools of courses in manual [illegible]oking, and sewing.

**Can one sense take the place of another?** Nature has so endowed us that if one sense is impaired or destroyed, the deficiency is made up to a certain degree through some other sense. The person who is blind may practically see with his fingers and ears. He can judge the form, contour, and surface of a body by means of the nerves of touch. He can learn to walk in comparative safety, finding his way by means of the sense of hearing. You have no doubt seen a blind man walking in the street constantly striking a stick on the pavement in front of him. The reflected sound of the tapping tells him how near he is to the wall beside which he is walking. The pilot of a river boat may guide his boat safely in a fog by constantly blowing the boat's whistle, determining where he is in the stream by the echo from the surrounding hills.

*A blind man walking in the street*

The blind man may learn to read by means his fingers. Passing his fingers ove

letters, he recognizes each letter by the sense of touch. By watching the lips of the person talking to him, the deaf man is able to understand speech through his eyes. He can tell from the movements of a person's lips just what letter or word is being spoken. Thus we see that in the person who has lost one sense the delicacy and intensity of the remaining senses is increased. A blind man may become highly educated in any branch of science or letters. In fact, a person may lose all his senses except one or two and still be able to get some idea of his environment.

According to their comparative importance in giving us information about our environment, the senses may be arranged in the following order: sight, hearing, touch, taste, and smell. This seems to be the best arrangement, though there may be some difference of opinion, especially as to which is the more important, hearing or touch.

## THE SENSE OF HUNGER

**What is the sense of hunger?** We feel the sense of hunger chiefly in the stomach. But we cannot definitely locate this sensation as we can that of a burn or the prick of a needle. When we are hungry the general idea seems to be that the sensation is in the stomach. In

this connection we must distinguish between starvation and hunger. Starvation is a condition of the body in which the tissues lack nutrition; hunger is a sensation.

In starvation the victim at first feels a very keen sense of hunger. After a while, as the starvation progresses the hunger diminishes, for the reason that the body has begun to burn itself or consume its own tissues. Weight and strength decrease, and finally the sense of hunger gives way almost entirely to the feeling of weakness and approaching death.

**What relation has the sense of hunger to the proper control of our diet?** The feeling of hunger does not stop immediately when we put food into our stomachs. If we eat rapidly the stomach may become quite full and still the sensation of hunger remain. For this reason we should eat slowly and stop eating before the sensation of hunger entirely disappears.

Every one of you must have noticed that if you eat a generous meal hurriedly you still feel hungry. But within half an hour after you leave the table, although you have eaten nothing more, the sense of hunger disappears. From this we learn, what it is wise to remember, that hunger disappears gradually. We will thus avoid filling our stomachs too full with an overabundance of food in a useless effort to satisfy hunger quickly.

## THE SENSE OF THIRST

**What is the sense of thirst?** Just as the stomach is associated with the feeling of hunger, so the *pharynx*, or throat, is associated with the sense of thirst. When we are thirsty it does not necessarily follow that the system has been deprived of water until health is threatened. Just as the sense of hunger is felt though there is no actual lack of nutrition of the tissues, so a feeling of thirst comes though there is no dangerous lack of water in the system. If the weather is warm and we exercise vigorously, more moisture than usual is lost from the body, especially by perspiration. Then in some way the need of the system for additional moisture is localized in the nerves of the throat and mouth. The back of the mouth becomes dry and the lips parched.

Thirst is more quickly satisfied than hunger. Drinking satisfies the sense of thirst within a few moments, long before the water can enter the circulation. This also proves that the sense of thirst is not due solely to a decreased water supply in the tissues of the body.

### QUESTIONS TO HELP THE PUPIL

1. What is the disease known as cataract? 2. What may be done to relieve this? 3. What is nearsightedness and what causes it? 4. What is the trouble in far-sighted eyes? 5. What is the distance at which

normal eyes can read print? 6. How may near-sighted and far-sighted eyes be corrected? 7. What is astigmatism and what is the remedy? 8. What are crossed eyes? 9. How may they be corrected? 10. What trouble is frequently caused by defects in the eyes? 11. From which direction should the light come when a person is reading? 12. What is eye strain and why should we be careful to avoid it? 13. Tell how light and good health are related; light and germs and bacteria. 14. Should a convalescent person remain in the light as much as possible? 15. Why is sunlight good for the hair? 16. Does the sense of smell vary in keenness in animals? 17. What animal has a highly developed sense of smell? 18. How do colds affect the sense of smell? why? 19. Can this sense be developed? 20. How is this sense related to good health? 21. What does a bad odor tell us about a food? 22. What is a flavor? 23. Has sugar a flavor? 24. What is an articulate sound? 25. What are the fundamental kinds of taste? 26. Can we perceive more than one kind at a time? 27. Tell about the difference in the nerves of taste in different parts of the tongue. 28. In what condition must a substance be before it can affect these nerves? 29. What is the effect of extremely hot or cold substances on the nerves of taste? 30. What temperature is suited to the best activity of these nerves? 31. What relation has this sense to good health? 32. Should we take food and drinks at either a very low or a very high temperature? 33. How does sound travel in the air? What do the waves of air produce on the ear drum? 34. To what mechanical device can we compare the ear? 35. How does the ear guard our health and safety? 36. Is the ear subject to disease? 37. What pleasures does the sense of hearing give us? 38. Can you always judge where a sound comes from? 39. How fast does sound travel? 40. How can you tell what an object is without looking at it? 41. What various things does the sense of touch tell you about an object? What characteristics can we not discover? 42. Can the nerves of touch be trained? 43. What trades and professions demand that this sense be very highly trained?

44. Can one sense be trained to take the place of another? Give an instance of this. 45. Can hunger be satisfied by eating hurriedly? 46. Can thirst be quickly satisfied?

47. What is the function of the eye? 48. What is the purpose of the lens? the retina? 49. What nerve carries the light sensations to the brain? 50. What commonly used mechanical device or machine is much like the eye? 51. Is all of the white outer coat of the eye opaque? 52. What is the transparent portion called? 53. To what may its structure be compared? 54. Over what part of the eye are the nerves of vision distributed? 55. Describe the iris. 56. When is the pupil of the eye small? When large? 57. In what part of the structure of the eye is the color? Is the iris ever black? 58. What color do you see in the pupil? 59. What and where is the aqueous fluid? the vitreous fluid? 60. How is blindness sometimes caused? 61. How are the movements of the eyes controlled? 62. Describe the olfactory nerves. 63. How do substances affect the sense of smell? 64. What two general kinds of olfactory sensations may there be? 65. What are the uses of the tongue? 66. Where are the nerves of taste located? 67. What are papillae? 68. What name is applied to the nerve of taste? 69. How is it connected with the brain? 70. What is the auditory nerve? 71. What and where is the tympanum or ear drum? 72. Describe the external ear; the internal ear. 73. What is the Eustachian tube? 74. What happens when a sound strikes the ear drum? 75. By what means are the vibrations in the ear drum transmitted to the nerves? 76. How is the sensitiveness of these small bones increased or diminished? 77. How are the auditory nerve filaments arranged? 78. Where are the nerves of touch located? 79. Are the sensations of cold, of heat, and of pain transmitted by the same nerve filaments? 80. Where are nerves of touch most abundant? 81. Name the two kinds of painful sensations. 82. Do sensations of pain always tell correctly where the trouble is? 83. Where does the sense of hunger seem to be located? 84. What is the difference between starvation and hunger? 85. What organ seems to tell us of thirst?

## VIII. A Study of Sleep

**What is sleep?** Sleep is a temporary suspension of the functions of the senses that give us our knowledge of the world about us. The great purpose of sleep is that the brain, the spinal cord, the nerves, and the muscles may rest. Though it is possible to rest without sleeping and thus partially restore the tired brain, nerves, and muscles, the full restoration of all the organs of the body to a condition suitable for further exertion is best secured in sleep.

**How long should we sleep?** The answer to this question depends upon several conditions. In early life a human being needs more sleep than he does in later life. The new-born infant sleeps nearly all the time. The baby of one year will sleep from twelve to fifteen hours a day. A child from one and a half to three years of age will sleep about twelve hours a day. From three to six years of age a child should sleep from nine to twelve hours a day; from the age of six to ten, from nine to eleven hours a day; and from ten to eighteen, from eight to nine hours a day.

The amount of sleep each person requires ries necessarily according to his occupation

and his physical condition. Some persons require, or at least indulge in, a longer period of sleep than others. A man or woman engaged in active work requires a minimum of seven hours' sleep, while eight hours would be better. The length of time a person sleeps is not the only thing to be kept in view; how he sleeps is also important. The more peacefully a person sleeps, the fewer the number of hours required. On the other hand, if sleep is troubled with frequent wakings, twitchings, and movements of the arms and legs, it is less refreshing, and more hours are required.

The man who engages in hard physical labor needs more sleep than the one engaged at desk work. Brain workers probably need less sleep than muscle workers, but they too need peaceful and refreshing sleep in order that the brain may rest and gather energy for further activities.

**What happens when a person does not get enough sleep?** If a person gets too little sleep, various disorders may result. These are manifested chiefly through increased sensibility and irritability, a diminished power of endurance, and decreased strength and vitality. These changes, with continued loss of sleep, may even make it difficult to sleep at all.

**What is insomnia?** *Insomnia*, or sleeplessness, is the inability to go to sleep when there is

opportunity to do so. Insomnia is one of the most distressing disorders. It is not so trying during the day, when the light is bright and we are mingling with companions; but it is terribly depressing to lie alone in the dark and not be able to go to sleep.

The wear and tear on the nervous system is extremely great in such circumstances, and when morning comes the sleepless one rises with his brain dazed, a general indisposition to engage in work or activity of any kind, and usually with little or no appetite.

If sleeplessness becomes chronic, that is, if it is continued for a long time, it may develop disorders of the brain and bring about *neurasthenia*, or nerve troubles. Insomnia may also diminish the power of the body to resist infectious or contagious disease. It tends to promote an early beginning of the diseases of old age, such as hardening of the arteries and diseases of the heart and of the kidneys.

**Do people ever sleep too much?** There are many persons who indulge in a greater amount of sleep than they actually require. Too much sleep, while not so harmful as too little sleep, is nevertheless injurious. A person who sleeps too much becomes dull and sluggish both physically and mentally, and may so weaken the power of his body to resist disease as to fall an

easy victim. Usually since such a person lacks energy and does not take much exercise, he is also likely to become too fat.

Sleep, like food, is necessary to existence. But too much sleep or too little sleep is harmful. As in all other things, temperance in sleep is highly advisable.

**When is a person inclined to sleep too much, likely to have the greatest inclination to sleep?** After eating a hearty meal a person inclined to sleep too much usually has a tired and sleepy feeling. A heavy meal excites the digestive activities and thus diverts a considerable quantity of blood from the brain and other parts of the body to the digestive organs. In sleep there is less blood in the brain than during waking hours. Thus a heavy meal, especially if the room is warm, brings about the same conditions in the brain as during sleep, and induces a desire for sleep. After a hearty meal, especially in summer, almost any one feels an inclination to sleep. In a church or a theater in the evening we often find many in the audience nodding. If we ask the reason we usually find that these persons have just eaten a heavy meal.

**Should we exercise immediately after eating?** Whenever it is possible, the hour immediately following the meal should be devoted to rest, even if that rest induces sleep. In fact, those

who have the leisure to do so would benefit by giving way to the desire to sleep after a meal. To take a nap after his noonday meal is good for the child's health. The health of grown people would also be improved if they could sleep for fifteen or thirty minutes after the noonday meal. Unfortunately, most people have no chance to indulge this desire to sleep.

Sleep is profoundly influenced by habit. If we are in the habit of going to sleep at a certain hour we are very apt to become weary and have all the symptoms of sleepiness when that hour comes. If we postpone our sleep beyond the regular hour we do not as a rule become more sleepy; for a time the feeling of sleepiness diminishes. If a person who is in the habit of going to sleep at ten o'clock in the evening is kept up until twelve or one o'clock, he then usually has great difficulty in falling asleep.

Usually physical fatigue is supposed to induce sleep. But we may be so tired that we cannot sleep. Most people are in the habit of sleeping at night, when it is dark, and thus are not able to sleep in daylight or if there is a brilliant light in the bedroom.

Sitting at the bedside of children and telling stories or singing lullabies is wholly out of place. The child soon learns that he goes to bed to sleep and not to be entertained.

**What changes take place in the circulation during sleep?** When a person is asleep the heartbeats are slower and there is a slight decrease in the natural heat of the body. But the temperature of the brain is apparently not decreased to any extent. Some physiologists believe that there is more blood in the brain during sleep than during waking hours. Most physiologists, however, speak of the condition of the brain during sleep as *anemic*, that is, having less blood in it.

Some experimenters think that there is an accumulation of carbon dioxide in the blood, and that this is either the cause or the result of sleep. It is well known that the amount of carbon dioxide excreted from the lungs is less during sleep than during the waking hours.

**What effect has sleep on the functions of the body?** The digestive and absorbing powers of the digestive organs are probably increased during sleep. The process of breathing becomes slower, and often deeper. Sometimes, when the nasal passages are obstructed in any way and the mouth is open, snoring results. If you keep your mouth shut you will not snore.

**How long can a person live without sleep?** How long a person can live without sleep can be determined only by experimental methods that are very cruel. For that reason little is known about it. The only way animals or human

beings can be kept from sleep is to torture them so that the pain produced is stronger than the desire for sleep. Then, if this torture is kept up until death occurs, who can say whether death was caused by lack of sleep or by an excess of pain?

A person in good health may lose one night's sleep without apparent injury, but he cannot lose a second night's sleep without some loss of efficiency. Prolonged sleep is much less injurious than prolonged wakefulness, though prolonged sleep is the sign of some grave disorder or change in the activity of the functions of the body, usually of a *cerebral* (brain) character. When an animal cannot be aroused by the usual methods, it has passed into what is called a state of *coma*, which usually ends in death.

**Are there other kinds of sleep besides natural sleep?** Sleep may be induced by various artificial means. Artificial sleep is most commonly induced by means of alcoholic drinks or a drug. The drugs which induce sleep are called *narcotics*. Opium and cocaine are types of narcotic substances.

**Is there any danger in using such drugs?** There is great danger in using drugs of this kind. They can be given safely only by a physician who has personal care of the patient. The use of many of these narcotics, especially opium

and its derivatives—morphine, heroin, and codeine—and cocaine, tends to produce a habit which, when once formed, is very difficult to break, and gradually destroys both physical and mental health.

Opium and its derivatives deaden pain, and their use is excusable when there is no chance for the patient to get well. But so long as there is a chance for the patient to recover it is far better never to administer any of these temporary reliefs than to cause him to form a habit which, after he recovers from sickness, is certain to destroy him.

Cocaine, which is derived from the dried leaves of a South American shrub called *coca*, is not a sleep-producing drug. But it has the remarkable ability of relieving pain and of causing a condition of emotional excitement. It is even more of a habit-forming and destructive drug than morphine, and its victims are utterly miserable when deprived of it. There is no more dreadful form of slavery than to be a morphine or cocaine user.

**Are there any laws to restrict the sale of such drugs?** Opium and coca leaves and the substances derived from them cannot be sold in this country except under strict regulations. Most of the states have strict laws regulating the sale of these dangerous habit-forming

drugs, and in many cities there are municipal laws to the same effect. Children, especially, should be protected from the evils which always attend the use of such drugs.

**Is artificial sleep, induced by means of drugs, beneficial?** As far as rest or restored energy is concerned, the sleep induced by the use of a narcotic gives very little of the benefit that comes from natural rest or real slumber. The drug relieves pain, but the possible harmful after-effect when the patient recovers is far greater than the good it does in relieving pain. But the use of narcotics is merciful in the treatment of cases that are hopeless and in easing the pain of the last hours of life.

**What other kinds of sleep are there?** *Hypnotism* is a form of sleep in which the sleeper is subject to the will of another. No one can explain the mystery of hypnotic sleep. The person who is under the influence of hypnotism knows nothing of his surroundings except as determined by the person who has placed him under that influence. The hypnotist commands, and the hypnotic obeys involuntarily. The hypnotic answers questions sensibly, performs acts of all kinds, and in general does any work he is told to do in a satisfactory manner. When he is called out of the hypnotic trance by the will of the hypnotist he has no memory of

what has taken place. In a way it may be said that he has been asleep, though hypnotic slumber is as different from real sleep as the sleep induced by the use of opium. The effect of

*A somnambulist*

such sleep has been said to weaken the mental power of the person hypnotized.

**What is meant by sleep walking?** The person who walks in his sleep, often acting exactly as if awake, is called a *somnambulist*, a word derived from two Latin words, *somnus*, meaning "sleep," and *ambulare*, meaning "to walk about." The somnambulist gets out of bed,

goes about the house, sometimes performs wonderful feats of athletic skill, and does many things better than he could have done if awake. When awakened the sleep walker has no recollection of anything that has happened. People who walk in their sleep often suffer serious injury by falling or running into things.

Nearly everybody now and then makes some movement in his sleep, crying out or talking, or sitting up, or gesticulating. These actions are usually remembered on waking as having taken place in dreams. But the somnambulist remembers nothing that occurred in his walk. Certain individuals are more subject to sleep walking than others. No positive remedy has been discovered for this unfortunate trouble. As a general thing simple food, outdoor exercise, light clothing, and regular habits will diminish the tendency to sleep walking and sometimes prevent it altogether.

**What is meant by being in a trance?** Persons who are in a trance are asleep in the sense that they have lost consciousness of the external world. But their brain often remains active. People in a trance write letters, answer questions, and do many things that they would perhaps not be able to do if they were in a normal condition.

There is another form of sleep in which the

body is more or less rigid, sometimes remaining in this condition for many hours or even days. This form of sleep is called *catalepsy*. This condition is, of course, abnormal, and seems to have no relation whatever to natural sleep. In other words, it is a disease.

**Is sleep very important?** When we consider that in a normal life of seventy years we pass nearly twenty-three years in sleep, it is evident that sleep is very important in its relations to our welfare. We are just as much alive while asleep as we are while awake, but it is a different kind of life. Sleep is a kind of passive life, growth, restoration of tissues, rebuilding of the broken parts of the system, rest and refreshment. From a physical point of view, sleep is quite as important as food and much more so than clothing. The fact that we spend almost one-third of our lives asleep should impress us with the importance of sleep. Sleep is essential to the health of the body. The hours of sleep should therefore be ordered as carefully as the hours of work or of play.

QUESTIONS TO HELP THE PUPIL

1. Have we any knowledge of the world about us while we sleep? why not? 2. Could we live without sleep? 3. What is the purpose of sleep? 4. How much sleep is required by young people from six to eighteen years of age? 5. Do brain [illegible] less sleep than muscle workers? 6. [illegible] get too little sleep?

7. What is insomnia? 8. Into what may chronic insomnia develop? 9. What does sleeplessness tend to hasten? 10. What is the effect of too much sleep? 11. Why does a heavy meal cause tiredness and sleepiness? 12. Is it beneficial to take a nap immediately after the noonday meal? 13. Is sleep much influenced by habit? 14. What is coma? 15. May sleep be caused by artificial means? 16. Name some narcotics. 17. Why is the use of narcotics very dangerous? 18. Is the trade in narcotics restricted by law? 19. Is sleep induced by means of narcotics beneficial? 20. What is hypnotic sleep? 21. What is sleep walking? 22. What may help to prevent it? 23. What is a sleep walker called? 24. Name some other abnormal forms of sleep. 25. Is sleep essential to the health of the body? why? 26. Is it important to have regular hours for sleep? 27. About how much of our lives do we spend in sleep?

## IX. A Study of the Bones and Muscles

**What are the functions of the bones?** The brain and the spinal cord, two of the most vital organs of the body, are inclosed in a strong framework of bones to protect them from injury (pages 93–97). The ribs, as we have also learned, act as a shield for the heart and other internal organs. But the protection of the vital organs is not the only function of the bones. They furnish support for the soft flesh of the body and give proportion to its parts. By their particular form and size, the bones give us the general shape that makes us recognizable as human beings as distinguished from the lower animals. All the bones of the body, joined together like a framework, are known as the *skeleton.*

**How many bones in the skeleton?** The skeleton is made up of two hundred and four bones, not including the teeth, the *patella* (knee cap), and the other *sesamoid* (occurring in tendons) and *supernumerary* bones that sometimes grow between the bones of the skull. The bones have an abundant supply of blood vessels and lymphatics and are covered with a membrane well supplied with nerves. This membrane is called the *periosteum* (around the bone). The large,

long bones are provided with a tube which is filled with a cheesy substance called the marrow.

**Of what are the bones composed?** We have learned (page 40) that for the development of the bones and teeth the child needs mineral elements in its food, particularly lime and phosphoric acid. These are the substances which build bones and give them hardness. But the bones do not consist of mineral substances alone. They also contain nitrogen in the form of protein, and gelatine-yielding bodies. This material gives them toughness and a certain pliability; that is to say, they can bend a little without breaking. The bones of little children are largely built up of nitrogenous (cartilaginous) materials. As they grow older, more mineral substance is added and the bones become harder and less pliable. In old age, the bones contain still more mineral matter and they are hard and brittle. That is why it is dangerous for older persons to fall. Their bones are no longer pliable and so break easily.

*The skeleton*

On the other hand, the pliability of the bones in childhood constitutes a certain danger. Since the bones are soft, they may be molded, to a certain extent, as we wish. By holding our bodies in proper positions while sitting, standing, or walking, our bones will grow as Nature intended they should. The round shoulders, the narrow chests, and the slouching gait that we so commonly see are the results of bad habits formed in childhood while the bones were soft. When the child is very small, of course, the parents must be depended upon to see that the bones do not become misshapen. Careful parents will not allow the child who is learning to walk to stand too long upon his feet. This is often the underlying cause of the defect called bowlegs or bandy-legs. Sometimes, also, the spine of the young child becomes curved because he is carried too often upon the same arm of parent or nurse. Thus we see the importance of knowing that the bones, if bent in a certain direction in childhood, will grow and harden that way permanently. Children,

*Standing erect makes the bones grow straight*

as well as parents, must recognize the danger in time, if deformity is to be avoided.

**What are the principal bones of the skeleton?** We have already learned how important are the skull and the spinal column, also how they are constructed (pages 93–98). We have read of the twelve pairs of ribs which guard the lungs and other important organs. The ten upper pairs of ribs are attached to the *sternum*, or breastbone, in front, and to the backbone in the back. The two lower pairs are attached to the backbone only, leaving the front ends free. These two pairs are called *floating ribs*.

*A bow-legged boy*

To the upper end of the sternum above the ribs are attached two thin, curved bones which hold up the shoulders. They are called the *clavicles* (collar bones). The outer end of the clavicle is joined to the *scapula* (shoulder blade). The shoulder blades are large, flat, triangular bones forming the upper framework of the back, lying one on each side of the backbone, to which they are fastened. At the outer end of each scapula is a socket into which fits the [redacted] upper arm bone.

The bones of the arm consist of

extending from shoulder to elbow, and two bones from elbow to wrist. The single bone of the upper arm is called the *humerus*, and the lower pair of bones the *radius* and the *ulna*.

The bones of the leg are much like the bones of the arm, only much larger and stronger. The single upper bone is called the *femur*. The lower pair of bones reaching from the knee to the ankle are called the *tibia* and the *fibula*.

The ankle and the wrist are each composed of a group of small bones. Those of the wrist are the *carpal* bones, eight in number, and those of the ankle the *tarsal* bones, seven in number. To the small bones of the wrist and the ankle are attached five bones, *metacarpal* and *metatarsal* respectively. To these last are attached the *phalanges* forming the short bones of the fingers and toes.

The large upper bones of the leg are joined to the hip bones (*pelvis*). The hip bones are, in turn, joined to the backbone. They are broad and flat and together form a support for the intestines and other organs of the abdomen. The outer edges of the hip bones may be easily felt on either side. All together these bones form the *pelvic cavity*, just as the ribs and backbone form the *thoracic cavity*. These two large cavities are separated from each other by diaphragm (see Book I, page 23).

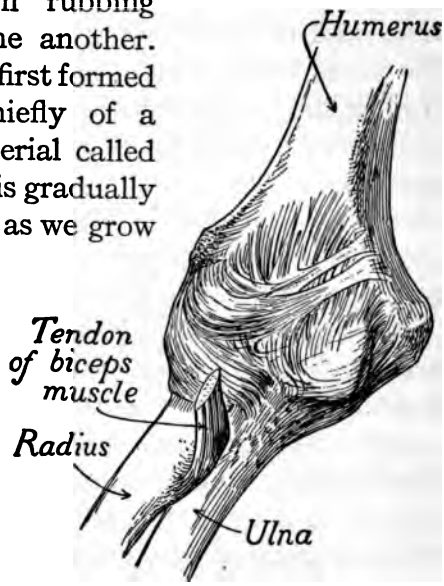
**How are the bones held together?** Although the parts of the skeleton are firmly joined, we know that we can move many of them freely. This is because there are many *joints* which permit the movements of the body. There are two principal kinds of joints in the skeleton. There is the *ball and socket* joint, which consists of a hollow in the end of one bone and a half sphere on the end of the other bone, just the size to fit perfectly into this hollow. The ball and socket joint permits great freedom of movement. You can swing your arm in any direction you wish. That is because there is a ball and socket joint at the shoulder.

Try to move your forearm from the elbow as you do your upper arm from the shoulder. You find that you can move it in only one direction. The reason is that the elbow forms what is called a *hinge* joint, which is much like the hinge on a door. There are other kinds of joints, each with characteristics to fit it for the particular kind of work it must perform.

**How are the joints prevented from falling apart?** The two bones forming each joint are held firmly together by tough bands of tissue called *ligaments*. These ligaments are much like rubber, for they stretch and contract as the bones move.

To make the joints move smoothly, the ends of the bones are covered with a thin m

To keep this membrane moist, the joints secrete a liquid which acts as an oil and prevents the bones from rubbing hard against one another. When bones are first formed they consist chiefly of a soft, elastic material called *cartilage*. This is gradually changed to bone as we grow older.



*Elbow joint showing the ligaments which hold the bones together*

**What are the functions of the muscles?** The skeleton framework and other parts of the bodily structure would help us very little unless there were some means to enable us to move about. For this purpose our bodies are provided with muscles. On each bone of the body are roughened places to which are attached the ends of the muscles which move that particular part. Muscles also give to the body elasticity. They conceal the bony angles of the skeleton, giving them a pleasing roundness and a graceful shape. There are about four hundred muscles on each side of the body.

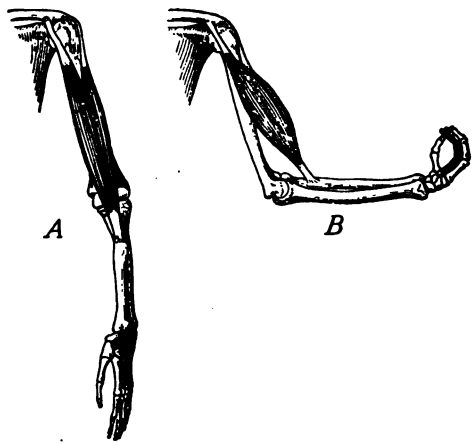
**What is the structure of a muscle?** A muscle consists of a bundle of long thread-like fibers firmly bound together. This bundle can contract and relax, thus causing the movement of the bones and other parts to which it is attached. Among the cells of the muscles run innumerable blood vessels and lymphatics bringing building material to the cells and carrying away waste products (page 86). In performing their work, the cells are being worn out constantly and new cells are taking their places.

At the ends of each bundle of muscular fibers are strong cords called *tendons*, which fasten the bundles firmly to the bones. These tendons cannot contract and expand like the fibers. Occasionally we find a muscle attached directly to a bone without the aid of a tendon. There is also a group of muscles, of which we shall soon learn, which are attached to skin and cartilage instead of to the bones.

**What controls the contraction of muscular fibers?** We have read (page 105) that the movement of the muscles is caused by an impulse carried from the brain or the spinal cord along the nerves to the muscles. The nerve, however, does not furnish the energy used in causing the contraction of the muscle. It merely acts as a key to unlock and set free this stored-up energy which the muscle has gathered from the

food and oxygen which the blood brings to it.

We can get a good idea of the movement of the muscle by studying the picture on this page. In this illustration we see the muscle of the upper arm attached to the upper end of the bone at the shoulder, and at the lower end to one of the bones of the forearm. It is quite




*Showing how the muscles of the upper arm raise and lower the bones of the lower arm*

*A*, muscle of upper arm at rest; *B*, muscle in action

clear that when this muscle contracts, or draws together, it will raise the bones of the lower arm.

Each muscle is connected with the spinal cord or the brain by its own nerve, which sends a separate nerve fiber to every fiber of the muscle. In this way the nerve carries the impulses which cause the movements of

the muscle. Indeed, the entire nervous system acts as a network of telegraph wires, flashing the orders of the brain to every part of the body and keeping the tiniest muscle busy at its own particular task.

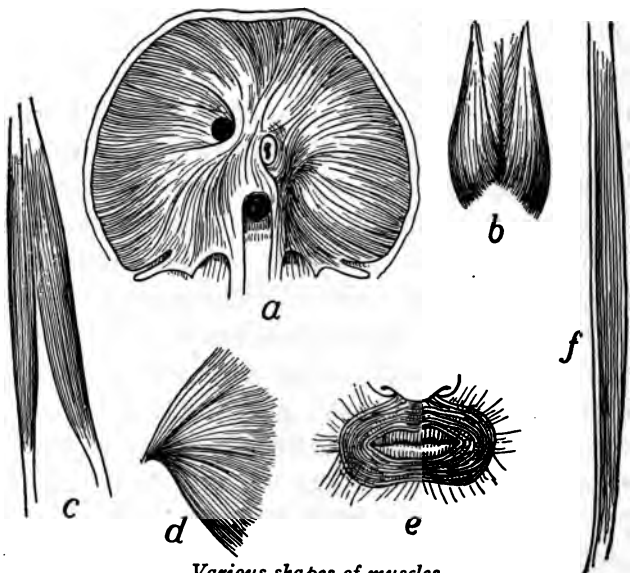
**What are the two great classes of muscles?** We have learned about voluntary and involuntary movements (pages 105–108) and how the former are controlled by the will, while the latter are controlled by groups of nerve centers branching off from the spinal cord. Muscles that perform voluntary movements are called *voluntary* muscles; those that perform involuntary movements are known as *involuntary* muscles.

The voluntary muscles form the red flesh of the body. Their fibers have light and dark stripes and the muscles are attached to the skeleton. Being under the control of the will, they take orders from the cerebrum (the large brain) (see page 96). The cerebrum, however, does not give them direct orders. It is like the superintendent of a factory: it has so many big tasks to occupy its attention that it leaves most of the work of directing the muscles to the cerebellum (little brain), to the medulla oblongata (spinal cord within the skull), and to the spinal cord.

The involuntary muscles are unstriped and pale in color. They are found in the skin, in

the coating of the blood vessels, in the lymphatics, and in the heart. They also line the walls of the digestive system and all the other internal organs, whose action they control.

**What are some of the principal muscles?** Some of the most important organs of the body are




*Various shapes of muscles*

*a*, sheet muscle: the diaphragm (from below); *b*, cone-shaped muscle: the "calf" of the leg; *c*, spindle-shaped muscle: biceps (back of thigh); *d*, fan-shaped muscle: right side of chest; *e*, circular or "whistling" muscle (around the mouth); *f*, strap or ribbon muscle: sartorius (inside of thigh)

nothing but large muscles, as for instance the *diaphragm*, which plays such a vital part in breathing. It is the broadest muscle in the body, forming the partition between the chest

and the abdomen. Then there is the heart, a hollow muscle, and the gullet or esophagus, a tube of involuntary muscle made of rings which swiftly contract during the act of swallowing. The ring-shaped muscle, in fact, is found surrounding all openings which relax and contract, such as the mouth and the socket of the eye.

Other muscles are of varied and curious shapes. Some are found in triangular and in four-sided sheets, some are shaped like a cone, some like a spindle, and others look like a ribbon. An example of the ribbon-like muscle is the *sartorius*, or tailor's muscle (from the Latin word *sartor*, meaning tailor), which is noted for being the longest muscle in the body. It runs down the front of the thigh and is used in crossing the legs. Then we are all familiar with the *biceps*, the long muscle of the upper forearm, extending from elbow to shoulder, and with the *triceps*, a similar muscle on the back of the upper arm. These are the muscles whose solid, bulging appearance is so much admired in the well-developed arms of an athlete.

**How does exercise affect the muscles?** When we use our muscles constantly in work or in play, they demand an increasingly large supply of blood. This makes the muscles expand, while their cells grow large and multiply.
supply of blood calls for more oxy

it, and thus more heat is generated in the muscle, bringing to the body that warm glow which always accompanies brisk exercise. Our muscles also take on a darker red hue, giving them the flush of health. On the other hand, if we neglect to use our muscles properly, they will become small and pale and flabby. They will have scarcely enough blood to be well nourished and not nearly enough to keep the body firm and properly shaped.

It should be remembered, however, that the muscles are fatigued by overwork. We should therefore take frequent periods of rest during long stretches of work or play and should avoid violent exercise when possible. Heart disease may arise from long-continued overexertion. In the next chapter, we shall learn more about the amount and kind of exercise necessary to keep our muscles in the best condition.

### QUESTIONS TO HELP THE PUPIL

1. Name three uses of the bones. 2. What name is given to the whole bony framework? 3. Of how many parts is it composed? 4. How are the bones nourished? 5. Name the materials of which the bones are composed and state the use of each kind of material. 6. Name and locate the principal bones of the skeleton. 7. What are the two kinds of joints? Illustrate. 8. Name the two great body cavities. 9. What keeps the bones from falling apart when they are moved about? 10. What e the muscles? 11. How are the muscles fastened to bones? 12. Tell all you can about the work of the

muscles. 13. How does the work of the voluntary muscles differ from that of the involuntary muscles? 14. Show how exercise changes the size, quality, and color of the muscles. 15. How many muscles can you name and find? 16. What danger is there in too violent exercise?

## X. Physical Exercise

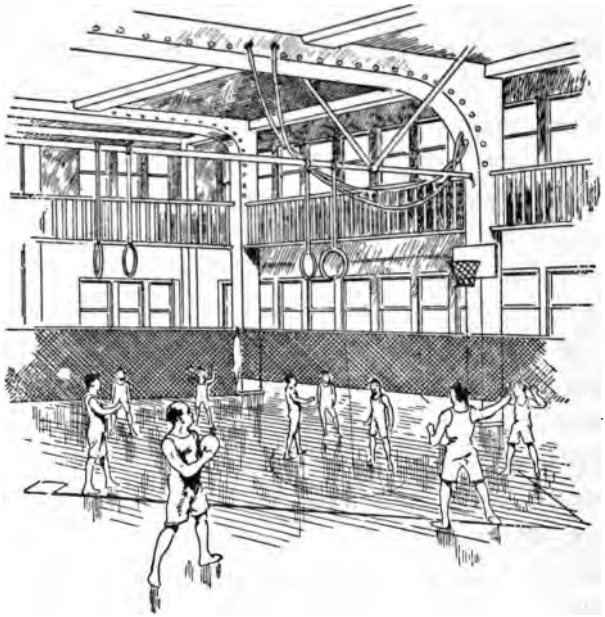
**What is the value of special physical training?** Ordinarily the child who plays out of doors will become thoroughly developed physically. The muscles of the legs are developed by walking and running, and the muscles of the arms by playing ball, drawing carts, and other play activities. The deep and rapid breathing which vigorous play induces will develop the muscles of the chest. Thus most of the child's muscles become developed in play. It is advisable, however, to aid and direct such development scientifically and to provide special exercise for certain needs. For this reason the gymnasium is an important aid to the playground.

**What is a gymnasium and how should it be equipped?** The gymnasium is, as a rule, a closed building where exercise may be taken during very cold weather, in rainy seasons, and even at night. Thus the gymnasium provides a place where the important process of physical development may be carried on when it would otherwise be prevented by outdoor conditions.

When properly equipped, the gymnasium is supplied with many different kinds of apparatus for physical development.

The most common appliances included in the

equipment of a modern gymnasium are poles, rings, ladders, swings of various sorts, "horses,"



*Interior of a gymnasium*

trapezes, and merry-go-rounds. Frequently also there is a running-track, as well as a swimming pool. In addition provision is made for the playing of basket-ball and other forms of indoor ball. For exercises on the trapeze, or for any other exercises in which there is danger of falling, padded floors or cushions should be provided.

The attendant should always take care to have

the gymnasium well ventilated. The temperature should always be lower than would be agreeable to any one not engaged in active exercise. While the temperature in the living room should be kept at sixty-eight to seventy degrees, the temperature in the gymnasium may properly be kept as low as sixty to sixty-five degrees.

**Are gymnastic exercises of value?** The value of gymnastic exercises cannot be denied. Though conducted within doors, such exercises, if properly directed and if the gymnasium is properly ventilated, are very beneficial. But the boy in the gymnasium needs supervision; in other words, his exercises must be performed under the direction of a teacher. To turn children loose in a gymnasium without any supervision or instruction with regard to the use of the various appliances found there might do more harm than good.

The instructor or supervisor should endeavor especially to prevent excessive physical exertion. An unusual strain or fatigue in the muscles of the body as a result of too much exercise is harmful instead of beneficial.

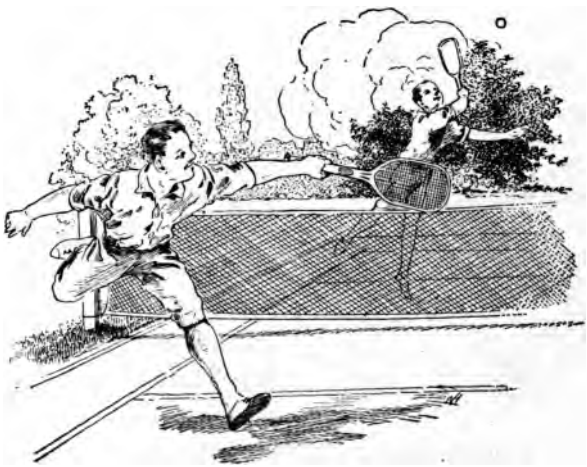
**What kinds of gymnastic exercises should be given?** In the gymnasium, children should at first go through very simple exercises. The exercises should gradually become more difficult as the muscular system develops and endurance

increases. Thus, by gradual training the child may learn to perform with ease exercises which he otherwise could not have done. Running, jumping, swinging, climbing, the swinging of Indian clubs, vaulting, and many other exercises are included in the general course of instruction.

A detailed description of the particular forms of exercises which should be practiced in the gymnasium cannot be given here. The wise and scientific superintendent will study each child and try to give him exercises in accordance with his particular needs. Children become very fond of gymnastic work when it is properly conducted. Its good effects are visible in hardened muscles, clearer eyes, greater mental activity, and increased physical endurance.

**What is the value of competitive games?** Competitive games, that is, games played by opposing sides, are better than ordinary play because of the added zest induced by the desire to win a victory. The sport of simply throwing or batting a ball is pleasant exercise, but it can in no way equal the interest of a game of ball in which each side is struggling for the victory. For this reason competitive games played in the gymnasium or in the open field, under good supervision, are effective in promoting physical development.

**Are competitive games dangerous?** There is one danger to be avoided in such games. The players are apt to put forth supreme efforts at critical moments in the game. Such efforts result in excessive strain or fatigue. Some games are much more dangerous on this account than others. First among such games is foot-



*Playing lawn tennis*

ball, though there is scarcely any game in which a child will take part with more enthusiasm. For children, the modified Rugby variety of football is preferable to the game played by college and university students. In football, extreme physical exertion is necessary, at least for a few moments at a time, in order to win the victory.

Competitive games with less danger to the child are baseball, basket-ball, and lawn tennis. Tennis, especially, affords excellent physical training, and without any very great danger of overexertion. Baseball is a national sport, and every boy will want to learn to play it. It is comparatively safe, full of interest, and requires much skill. Every child should be encouraged to play baseball or some modified form of it, such as volley-ball, indoor baseball, and handball.

*Riding a bicycle. A beneficial outdoor exercise*

**Are running games the proper thing for children?** Running competitive games are interesting, but they require probably a greater degree of physical exertion than any other sport. There is danger to the heart and the organs of circulation in the supreme efforts put forth in such games in order to win, and young folks especially should not take part in them.

A few years ago almost everybody rode the bicycle for pleasure. Bicycle riding is delightful and beneficial, but when long runs at a rapid rate of speed are made, as in racing, extreme

fatigue and great injury may result. In general, competitive games are to be encouraged, but always with wise supervision.

QUESTIONS TO HELP THE PUPIL

1. Why should children's play always be scientifically directed? 2. What is a gymnasium? 3. Why should exercises in a gymnasium be under the supervision of a teacher? 4. Is excessive physical exertion in exercise or play hurtful? 5. What should be the temperature in the gymnasium? 6. What is the result of properly conducted gymnastic work? 7. Why are competitive games, like baseball, beneficial in promoting physical development? 8. What danger should be avoided in playing? 9. How does an unusual strain or fatigue affect the muscles? 10. What are the dangers of competitive games? 11. Under what conditions is bicycle riding beneficial?

# XI. Health Habits

**Forming health habits.** In all our study of the organs of the body and their functions, we find that the formation of health habits depends not so much on certain acts that we must perform at certain times, though these are also important, but more on our determination not to do certain things that do not agree with laws of nature.

*An incorrect sitting position*

**Natural positions.** Nature intends that when we are on our feet we shall hold our bodies erect. In that position all the organs of the body can best perform their functions. When we sleep the reclining position is the natural one. When we rest the natural thing to do is to sit down. So it is with breathing, sleeping, eating. The

natural way is the correct way. When we bend our backs over a desk or assume a crooked position in standing, the organs of the body are cramped and cannot perform their functions in a harmonious way. But if we hold our bodies erect in a natural way, something tells us immediately that it *is* the natural and correct way. You may prove this for yourself. Stand up straight with the abdomen drawn in, the shoulders thrown back and chin up, your arms hanging easily at your sides. With the feeling of erectness there will be a new vigor in all your body. Your breathing will be deeper. You will have an entirely new attitude toward all the world, as if there were nothing you could not win if you set yourself to it.

**Health habits in relation to the digestive functions.** In this book we have learned a great deal about the digestive organs and the way the work of digestion is carried on. We have also learned about the wonderful mechanism of the nervous system and the senses that keep us in touch with the outside world. In the course of our study the necessity for many health habits has been discovered. In order to impress these more strongly on our minds, we will again go over the main points of the reading.

**What is the purpose of food?** We know that the purpose of food is to maintain life. We eat to

live. In the process of living, in every movement we make, both voluntary and involuntary, in every sensation, in every thought that passes through our minds, tissues of the body are used up and must be replaced by digested food elements. In the growing age the body needs still more nourishment, for then, besides repairing the waste tissues, new tissues must be formed. At the same time the natural temperature of the body must be maintained.

**Do the different classes of food all serve the same purpose?** No, the different classes of food do not all serve the same purpose in nutrition. Protein is the principal building material of the body, and is found in every tissue in varying quantities. It is the essential material composing the muscular tissues, the skin, the nails, and the hair. It is one of the important substances in the blood, the bones, the nerves, and the brain. It is present in small quantities even in fat. Protein foods all contain albumin. Such foods as eggs, lean meats, milk, nuts, peas, beans, and oats are rich in protein.

The carbohydrates are the chief heat and energy producers. Starch and sugar are called the fuel of the body. When there is an excess of carbohydrates for immediate use, these food elements are used in forming fat tissues, or are stored away in the liver or the muscular tissues

of the body. Fats and oils are formed of essentially the same elements that exist in the carbohydrates. They are also used in nutrition for practically the same purpose as the carbohydrates—that is, to furnish heat and energy. A greater amount of heat is produced in the body by fat or oil than by any other food element of the same weight. It is evident that fuel foods should be used in moderation in the hot days of summer. Protein foods also furnish heat, and this heat is given off promptly. Protein cannot be stored for future use as is the case with sugars and fats. Hence it should be used in moderation in hot weather.

The mineral foods are used in building bones and teeth. They also furnish to the blood and tissues the alkaline substances needed in making new cells. Then, too, secretion of digestive fluids is assisted by mineral matter. As a general rule we do not get enough mineral food. In the preparation of many foods, the natural mineral content is greatly reduced. We have learned how the mineral and other valuable food content of wheat and corn is greatly reduced by the modern method of milling. The housewife, also, is inclined to be too careful in removing the outer coverings of vegetables and fruits. By discarding these parts, the mineral content of [illegible] ned. It is better to eat

the skins and outer coverings of foods, if they are thoroughly cleaned, than it is to discard them. The activating elements of our food, which have been called vitamines, reside chiefly in the bran of cereals and the skins of fruits and vegetables. The health is injured when these elements are removed.

Children especially need mineral foods for the construction of bones and teeth. Proof of this is found in the large mineral content of milk, the food we may take as a model in the proportions of food elements it contains. A great many children have poor teeth. This is largely the result of the excessive eating of candy and sweet stuffs to the exclusion of foods containing bone-building material.

**What is a balanced ration for a grown man?** We have learned (Book II, page 25) that the proportions of nutritive elements in the food for children should be approximately as follows: mineral matter, one; protein, four; fat or oil, six; and sugar and starch, eight. The proportion of these elements in the ideal ration of a grown man differs considerably from these figures. We find (page 19) that the amount of carbohydrates is greatly increased, and the fat much reduced.

**What is the result of an unbalanced ration?** We have learned (page 20) how to tell whether

a ration is well balanced. Any great variation from such a ration is more or less dangerous to health. Experience of a scientific character and natural taste or instinct are the best guides in securing a balanced ration.

That the proportion of the elements of nourishment in the food of human beings is of great importance in the development of the body is clearly demonstrated in the physical characteristics of different races. Americans, Canadians, Australians, and inhabitants of northern Europe are large in stature. This is because the protein content in the food is high. People of Greece, Spain, and Italy are generally small in stature, because the protein content in their food is low and the carbohydrate and fat content is high. It is also evident that these persons of large stature are inhabitants of regions where many kinds of cereals are raised and where food of all kinds is in greater abundance.

**Simplicity in diet.** One of the fundamental necessities in diet is simplicity. We have learned that there must be variety in our food. That does not mean that we must have all the different kinds of food at one meal. That would be a very dangerous proceeding. We should not eat more than three or four kinds of food at a meal. But at the next meal or the next day we may choose other varieties, and so in the

course of three or four days go through a wide range in the kinds of food we eat.

Another good rule to observe is to eat only one thing at a time. That is, do not mix all the kinds of food together at each mouthful. Digestion is best carried on when only one kind of food is present at a time. Foods also lose their respective tastes and flavors when mixed with other foods, and we are deprived of the real enjoyment of eating. Chewing each food well gives us the full benefit of its taste.

*Often in pastry the elements are mixed closely together, causing imperfect digestion*

Simplicity in diet means, too, that we should avoid rich foods. These we have learned would upset the balance of the ration. Rich foods contain much sugar or much fat or oil, or excessive protein. In rich foods the elements are very often mi closely together, as in pastry and confe

The digestion of such foods must be imperfect, for one kind of food is digested in one part of the digestive canal and another in another part.

The scripture story of Daniel is an excellent illustration of the result of simplicity in diet or the avoidance of rich foods. At the court of Nebuchadnezzar, Daniel and three companions were to be trained with a number of children, as pages to the king. They were kept at the palace and fed on rich food and wine from the king's table. But Daniel asked that he and his three companions be given plainer food. At the end of the period of training their health was found to be far better than that of the others: "Their countenances appeared fairer and fatter in flesh than all the children which did eat the portion of the king's meat."

"And in all matters of wisdom and understanding that the king inquired of them, he found them ten times better than all the magicians and astrologers that were in all his realm."

**Health habits in eating.** In every home, children of the growing age have little to say about the selection and preparation of food. The wise mother knows what each child should have, and adapts the quantity to the and state of health of each one. She ety of foods so as to give all the

tissues the needed nourishment, and she prepares the food for her family in delicious forms so that, because of its attractive taste, the food may do them the greater good. But the child should be told the reasons for having a simple diet and what each kind of food does for him. It is surprising how soon he will take a deep interest in these things.

After the food has been selected and prepared, eating is simply the act of putting the food into the mouth, grinding it with the teeth, and swallowing it. The digestive organs do the rest, turning the food into digested material for the use of the various tissues and organs of the body —bone, muscle, fat, skin, and so on. But the simple acts we perform in the process of eating have all the influence in the world in determining how the rest of the process shall be carried on—whether the work shall be done thoroughly or whether the body shall be cheated of the sustenance it needs. It is then that much of the responsibility falls upon the child, and it is necessary for him, in order that he retain good health and build a strong and sturdy body, to form good habits in eating.

**What is the first step in the digestion of food?** The first step in the digestion of food is the process of chewing. Chewing [illegible] essential process. To be properl[illegible] [illegible]d,

especially starches, must be ground into fine particles and mixed with saliva in the mouth. Unless this first process is well done, the rest of the digestive process will not be perfected as it should be and the body will not be properly nourished.

**Health habits in the care of the mouth.** The first care should be the development of good temporary and permanent teeth. We have learned that, for this reason, the food must be rich in bone-building and tooth-building material, that is, in mineral substances, especially lime and phosphoric acid. The child should drink plenty of milk, for that food contains these minerals in the proper proportion.

The next care should be to take measures to preserve the teeth. Children's mouths should be carefully inspected at regular intervals and bad teeth promptly cared for.

*Molar with decayed spots*

**The habit of keeping the teeth clean.** An indispensable health habit is to clean the teeth well after every meal, using a toothbrush and powder or paste effectively. If this is not done, fermentation may take place, with formation of acid which softens the teeth. Bacteria will find lodgment in the mouth and start the process of decay in the teeth, or else

the bacteria will be carried into the body to work harm wherever they go. Most of us know the painful sensation that tells us that a tooth is decayed and the nerve exposed. Is it not wiser to keep the teeth clean and so avoid the pain of toothache, and at the same time make sure that the process of chewing will be well performed?

**What not to do.** The mouth cannot be kept free from bacteria, nor is it necessary that it

*Drinking from a public drinking cup may cause illness*

should be. Nevertheless we should practice the utmost cleanliness. The bacteria that enter the mouth through filthy habits are very undesirable. To prevent this the hands must be kept away from the face as much as possible. The fingers are constantly in contact with things that have been handled by other people

knobs, books, desks, all may be covered with dangerous bacteria and germs. If we touch them and then put the fingers to our lips or into our mouths the bacteria are given opportunity to enter our bodies, in many cases causing severe sickness.

Never drink from public drinking cups. Always have your own and keep it clean. Never use a spoon or fork that some one else has used unless it has been washed and sterilized. Do not chew your pencils or put pins into your mouth. The only things you should ever put into the mouth are good clean food and drink, and a clean toothbrush.

Chewing gum or any like substance is a source of great danger. The chewing causes continuous activity of the salivary glands, and large quantities of saliva are discharged into the mouth. The glands thus become overworked and worn out, and finally become unfitted to play their part in the digestive functions.

People who chew gum do so sometimes in order to disguise a disagreeable odor from their mouths. The bad odor could usually have been prevented by habits of thoroughly cleaning the teeth. Others chew gum to tickle the sense of taste continuously. They do not stop to think that this practice is a sure way to weaken sense of taste. Eventually, if the habit is

continued, the real pleasures of the sense of taste will have disappeared. Besides, we are then no longer able to depend upon the sense of taste in our selection of food, thus avoiding what is not good for us. Moreover, gum chewing is a disgusting habit.

Biting the finger nails is also a very dangerous habit. All kinds of bacteria and poisonous substances gather under the finger nails. Think what it means to get all these impurities into your mouth. Besides, the fingers become very unsightly if the habit is continued any length of time. The habit once formed is hard to break.

**The process of digestion in the stomach.** We have read (pages 47–50) how, when the food has been well chewed and every particle mixed with saliva, it is carried by the tongue back to the esophagus and there sent into the stomach by the automatic action of the esophagus muscles. Thereafter the process of digestion goes on in an apparently independent way and we are not conscious, to any extent, of the activity of the digestive organs, unless digestion goes wrong.

We have read of the strong muscular movements of the stomach and intestines (page 53) and how these movements as well as the process of secretion of the digestive fluids are affected by the state of mind of the individual.

For this reason let us form the habit of always being in a cheerful frame of mind. Especially at the dining table is this important. There the conversation and associations should be pleasant. Disagreements should be forgotten. The more agreeable the companionship, the more attractive the surroundings, and the better the humor, the more effective will be the workings of the digestive organs, and the more nourishing will be the food.

*Being cheerful on a rainy day is a good health habit*

We should not fall into the habit of grumbling at what cannot be helped. Many persons injure their health by being angry with the weather. Whatever the weather may be, hot or cold, wet or dry, windy or calm, we should endeavor to make the best of it. As James Whitcomb Riley says:

> "'T ain't no use to grumble or complain.
> It 's jist as cheap and easy to rejoice.
> When God sorts out the weather and sends rain,
> Why, rain 's my choice."

**Some hindrances to digestion after the food is swallowed.** To play, to work, or to exercise

violently immediately before or immediately after eating hinders the digestive process in the stomach and intestines. Blood is needed by the alimentary organs in the process of digestion. When we use our muscles vigorously the blood is drawn away from the stomach and intestines to provide the muscles with the necessary energy. In this way, deprived of the necessary blood, the process of digestion cannot do its work thoroughly.

Regularity in the time of meals is another necessity for good digestion. Habits of regularity accustom our digestive organs to expect food at a certain hour. The process of digestion is all ready for it at that hour. So if we eat a meal an hour later than the usual time, and the next day an hour earlier, the process of digestion will be upset and the organs do not know when to be ready for their wor

*On well-regulated farms the dinner bell rings at a certain hour each day*

**What are the principal digestive ferments in the stomach?** We have read that the principal digestive ferments in the stomach are rennin and pepsin. Rennin plays an important part in preparing for the digestion of milk, and pepsin in the digestion of protein.

**What is the function of a digestive ferment?** The function of the digestive ferments is to break up each particle of food into its chemical elements or into simpler combinations of substances. We have also read how the food changes from alkaline to acid and from acid to alkaline as it passes through the digestive organs. In the mouth the saliva makes the food alkaline; that is, it adds lime, magnesia, and sodium. In the stomach hydrochloric acid secretions act on the alkaline properties of the food, which then becomes acid. In the small intestines, new secretions in turn overcome the acidity of the food, which then gradually again becomes alkaline. These changes are essential in digestion.

Usually the stomach is empty three or four hours after eating. This makes it clear why we should not eat at frequent intervals. New food mixed with the old hinders the process of digestion or causes it to be imperfectly performed.

**What are the digestive ferments secreted by the small intestines?** We have learned that the

principal digestive ferments secreted in the small intestines are bile, secreted by the liver; and diastase, trypsin, and lipase, all secreted by an organ called the pancreas. Diastase acts on the carbohydrates in the food, continuing the process begun by the saliva in the mouth. Trypsin acts on the protein substances which had been converted by the pepsin in the stomach to peptone and reduces them to amino acids. The lipase acts on the fat or oil and separates it into glycerol and fat acid.

**The absorption of digestive food substances.** Nutrients, the nutritious elements of the food, are principally absorbed in the small intestines. In the walls of these intestines, in addition to the vessels which permit the secretion of the digestive ferments and fluids, is an extensive system of absorbing vessels. These absorbing vessels take up the nutrients prepared by the digestive ferments and send them into the blood.

The digested proteins and carbohydrates are sent principally through a vein known as the portal vein which leads to the liver. The fats are absorbed by vessels known as lacteals, which send them directly into the blood stream. There is no special duct for the mineral substances. These enter the blood together with the carbohydrates, fats, and protein substances

**What further process takes place in the preparation of food for use in the body?** The portal vein, which receives the final products of the digested proteins and carbohydrates, carries these substances to the liver. There most of the sugar is changed to a substance called glycogen and stored away to be used as the body needs sugar for heat and energy. Glycogen is also stored in other tissues of the body. Another important work of the liver is to separate a waste product called urea from the digested protein. This substance is then carried to the kidneys, which in turn send it out of the body.

**What health habits are necessary to the proper functioning of the liver and kidneys?** The liver and the kidneys are very important organs. They remove poisonous substances from the blood. If the kidneys or the liver should cease to act, the body would soon die from poisoning.

The kidneys need water in order to carry on their functions properly. So we see that the practice of drinking water freely to aid digestion is also beneficial to the kidneys. It dilutes the poisons gathered by the kidneys from the blood and helps to remove them.

The danger of an unbalanced ration has been impressed upon us. When there is more protein than can be used in the body the liver breaks it up and sends it to the kidneys as waste

products to be excreted. Thus it is clear that overeating or a too great content of protein in the ration places too great a burden on the liver and the kidneys and they become worn out.

The excessive eating of sugars, candies, and confections places an added burden on the liver. When there is too much sugar in the food, the liver is overworked to take care of it. When there is more sugar than can be stored away or burned, the liver tries to get rid of it by sending it to the kidneys, which then send it away through the bladder. An excessive amount of sugar in the urine is a symptom of a disease called diabetes. Other similar faults in the diet cause other diseases of the kidneys. Thus we see the importance of simplicity in diet and a well-balanced ration, besides their value for the proper nutrition of the body (page 15).

**The effect of alcohol on the kidneys and the liver.** We have been warned against the use of alcoholic drinks. Alcohol is very injurious to the kidneys and the liver, often causing inflammation. Alcohol at first stimulates these organs to excessive action in an effort to get rid of it, but the final result is always that the functions of the body are disturbed and its organs diseased.

**The danger of retaining waste products of digestion in the body.** Waste products of digestion form very poisonous substances. If they are

not promptly and regularly eliminated from the body these poisons are reabsorbed into the blood. Thus the whole body is poisoned and death is often the result.

**Habits which tend to make a healthy blood stream.** We have read (page 80) how the blood is supplied with the nutrients obtained by the process of digestion. The blood stream carries these nourishing materials to all tissues of the body. We have also learned how the blood carries waste products away from the tissues and from the digestive organs to the excretory organs. The blood is the oxygen carrier and contains the wonderful white corpuscles that guard our health by attacking and destroying the dangerous germs that find their way into the body. Thus we see how important it is to keep the blood stream in a healthy condition. Pure air, deep breathing, a well-balanced ration, temperance in eating and drinking—in fact, all health habits tend to make a healthy blood stream.

**The nervous system.** The functioning of the nervous system is very wonderful; in fact, we cannot understand it entirely. We know that the nerves are fine white threads extending throughout the body, either as separate fibers or bound together in bundles called nerve trunks. They carry impulses to the brain and

spinal cord and another set of nerve fibers carry the impulses or *excitations* back to the muscles, stimulating them to action.

Apparently these nerve fibers are all alike in the work they do — that is, the work of transmitting impulses — just as telegraph wires are very much alike although the messages sent over them vary greatly. But certain nerves are provided with peculiar endings or "*end organs*," as they are sometimes called, on or near the surface of the body, that are specially adapted, in each case, to the reception of some one particular kind of stimulation. For example, the end organs of the nerves of sight can be stimulated by light waves, but by nothing else. The end organs of the nerves of hearing can be stimulated by sound waves, but by sound waves only; and so with the end organs of all the nerves of special sense.

There are at least five such groups of modified nerve endings, having fibers extending from the surface of the body to the spinal cord, or brain, or both. The nerve end organs of sight are in the retina in the back part of the eye. The nerve end organs of smell are in the mucous membrane lining of the nose. The nerve end organs of taste are chiefly in the tongue. Those of hearing are in the inner ear; those of touch are chiefly in the skin.

There are also other less specialized nerve endings, as those that give the sensations of hunger and thirst, heat and cold, pain and comfort, and the feeling of the movement of the muscles. But these last are not usually classified under the term "nerves of special sense."

*An incorrect reading position*

**Health habits in relation to the sense of sight.** The sense of sight is one of our most precious possessions. Think what it would mean to live always in darkness, and not to be able to see the beautiful and interesting things in the world about us. You can understand how important it is that we take the utmost care of our eyes.

Never read unless the light is good. If you do so the nerves of the eye are made tired and

finally weakened. Never read with the light shining directly into the eyes. You know the after effect of looking directly at a bright light. A black spot appears before the eyes and we are temporarily blinded. The light should shine on your work from behind, preferably over the left shoulder.

Never rub your eyes with your fingers. You have been warned not to put your fingers to your lips nor into your mouths and not to use public towels because of the danger of germs and bacteria. The same caution applies to the eyes. The best rule is to keep the hands away from the face as much as possible.

If something gets into your eye—say a speck of dust or a cinder—do not rub the eye. If you do so the particle may become imbedded in the eyeball or in the eyelid, so that its removal will be very painful. The best thing to do is to draw the upper lid down over the lower, or the eye may be bathed. The eyelid may also be folded back upon itself and thus the foreign object be brought to view. It then can be removed with a clean handkerchief. If neither of these methods helps, a specialist should be consulted.

Defects in the eye should promptly be attended to. An expert optician can correct many of them. If eye troubles receive no

attention they become worse and cause other troubles, such as headaches and nervousness. The child with poor eyes cannot do his work in school as he should.

*A correct reading position*

**Health habits and the sense of smell.** The sense of smell is a very important sense in relation to health. It warns us of many dangers, such as bad food, or impure air, which we could not otherwise avoid. A neglected cold may cause chronic catarrh or thickening of the mucous membrane and the secretion of large quantities of mucous. These conditions decrease or entirely check the activity of the end organs of smell. Thus we must always give prompt attention to colds or any affection of the nose.

**Health habits and the sense of taste.** We have learned how the sense of taste warns us

injurious food. It is also important in the digestive functions as it causes the digestive fluids to flow. The sense of taste is injured by extremely cold or warm food substances. We have learned that the temperature of food and drink should not be below fifty degrees nor much higher than the temperature of the body. They certainly should never be hot enough to burn.

*Hot food should be cooled or it will injure the sense of taste*

Alcoholic drinks, too, are dangerous to the sense of taste, for the alcohol so acts on the nerves with which it comes in contact that it produces a desire for more. So here we have another vital reason for avoiding alcoholic drinks besides the injury they cause to the internal organs and the functions of digestion.

**Health habits and the sense of hearing.** The sense of hearing guards us from many dangers and is also the source of much pleasure as well as an avenue of knowledge.

Colds and inflammations are dangerous to the delicate nerves of hearing and should be

promptly cared for. The ear should also be kept clean to prevent the wax secretion from accumulating. Never blow or shout into any one's ear. The sudden shock may seriously injure the sense of hearing. The drum of the ear is a delicate instrument and may be broken easily. Do not blow your nose violently when your mouth is shut. It may hurt your hearing.

Adenoids often affect the sense of hearing as well as the sense of smell. Adenoids are tissue growths at the back of the nasal passages and sometimes completely close the air passages to the nose and the inner ear. Adenoids should promptly be removed by a surgeon. The child with adenoids cannot breathe through his nose as he should, and the effect is far-reaching in its danger, both physical and mental.

**Health habits and the sense of touch or feeling.** The sense of touch gives us more information and of a more varied kind than any other sense. In a great measure it may make up for the other senses if we should be so unfortunate as to lose them. The sense of touch may be very highly trained. We have evidence of this in the skill of professional men, like the surgeon, the skilled mechanic, the musician and the artist.

It has also important rela[illegible] health, for it warns us of many dan[illegible] avoid them. The [illegible]

as well as that of the whole nervous system, is dependent on the state of health of the whole body. We have learned that most good health habits indirectly improve the health of the blood stream. In the same way good health habits all tend to improve the condition of the nerves.

**Alcohol and the nerves.** We have read of the dangerous influence of alcohol on the digestive organs. Alcohol inflames the mucous membrane in the stomach and digestive organs. It numbs all nerves with which it comes in contact. Moreover the liver and the kidneys are overworked in the effort to get rid of the poison. The entire system is affected, the tissues in some parts of the body harden, the nerve tissues are injured, the senses become blunted, and frequently the brain is affected. With all these terrible effects of alcohol it is evident that we should not permit ourselves to indulge in drinks containing alcohol. No man can be successful in anything he undertakes if he uses alcohol freely.

**Laws regarding the sale and use of alcohol.** For more than fifty years Maine has been a prohibition state; that is, a state where the sale of alcohol is forbidden. One by one other states have followed her example until prohibition has become the law throughout the United States. By act of Congress, as a war measure,

the making of whisky was prohibited during the continuance of the European War. Medicine makers generally are required to state on the labels of their bottles the amount of alcohol or other poisonous drug contained in the bottle. The aim of this last requirement of the law is protection of the people against taking dangerous drugs through ignorance of their presence in the medicine.

The danger of using alcoholic liquors is now recognized by the great governments of the world. The government of Russia realized that an army composed of alcoholics could not win victory and therefore rigidly restricted the use of vodka during the early part of the war. Other nations restrict the use of alcohol.

Indirectly legislation requiring employers to pay compensation for injuries, affects alcohol users also. Employers are far more careful than formerly about hiring persons who deaden their sense of responsibility by the use of narcotics, and who therefore easily make themselves liable to serious injuries. The rapid multiplication of street cars, automobiles, factories, machinery of all kinds, makes a crying need for the abolition of any custom that clouds the mind and unnerves the hand.

**What is the effect of tobacco on the nerves?** We have read of the dangers of drinking coffee, tea, and cocoa, because of the alkaloids contained in them. In this book (pages 160–162) we have read of other poisonous alkaloids, such as cocaine, morphine, and opium. Still another substance belonging to this class of poisons is nicotine. Nicotine is the alkaloid contained in tobacco. In its pure state small quantities of nicotine will cause death. When tobacco is first used, even in small quantities, the nicotine causes extreme nausea, violent vomiting, and many other symptoms of severe poisoning. When used continually the system becomes accustomed to it so that large amounts of tobacco may be tolerated without causing any apparent evil effects. But the process of poisoning goes on just the same, gradually breaking down the nerve cells, hardening the arteries, and injuring the entire system. Many medical authorities think that smoking tends to promote cancer of the lip, tongue, and throat.

*A tobacco plant*

Many employers will not hire men who smoke. They know the effect of nicotine and they know that men who use

tobacco cannot do as good work as those who do not use it. Thomas A. Edison does not like to employ tobacco users. Henry Ford prefers not to have them in his factories. So we see that the person who uses tobacco is deprived of a chance in the race for success. He not only is denied employment but he so injures his strength and nerves that he could not do good and effective work if he had the chance. Tobacco smoking is also very frequently the cause of fires in barns and factories.

*Applying for a position. Many employers will not have a boy who smokes cigarettes*

**Laws regarding the sale of tobacco.** Many of the United States now forbid and punish the sale of cigarettes to minors. Some forbid the manufacture and sale of cigarettes at any age. In spite of these restrictions, the tobacco habit is widespread. But there is an increasing number who feel that the use of tobacco should be stopped, simply as a matter of decent manners,

to say nothing of stronger reasons. "As citizens of a Republic," says one of our leading educators, "and joint owners of the atmosphere, we, the one million men and the forty million women who do not smoke, have the right to ask the others to put away their cigars when they are in our company. We ask them for a free passage through the world, with *pure air all the way.*"

**Good habits of sleep and what they bring.** Sleep is the resting period of the nervous system. The muscles may be rested by keeping the body motionless. This also rests the nerves. But the real rest of the nerves, when the worn-out nerve cells can be built up again for further work, is in sleep. The nerves control all movements of the muscles, including breathing and the beating of the heart. We have learned that the nerves also receive and transmit all stimulations, sending them to the brain and spinal cord, the central stations of the nervous system. With this enormous work to perform, we can understand how much the nervous system needs frequent periods of rest.

Sleep is not only the resting time of the nerves, the brain, and the muscles, but it is also the mending time. During the day, in our play and work, the tissues of the body are used up very fast, so fast indeed that the building-up process cannot keep up with it. In sleep the

muscles and nerves are quiet, there is little or no wear and tear, and the building-up process has a chance to catch up in its work of renewing the body and preparing it for further work and play. So we see how important sleep is in relation to health.

*Regularity in going to bed is a good habit*

We have read that the windows in our sleeping rooms should be wide open, or better still that we should sleep on porches or out of doors. Another important health habit is going to bed at a certain hour each night and getting up at a regular time each morning. All the activities of the body require regularity. We have learned that we must eat at regular hours, so that the digestive organs may know when to be ready for the food. In the same way the body will prepare for sleep and waking at certain hours if we establish the habit of regularity, and

so the restoration work will be done thoroughly and well.

The position in which we lie while sleeping is also very important. Just as in standing or sitting, we should avoid any posture that would cramp the internal organs, interfere with their proper functions, or cause the body to take any unnatural attitude. Raising the head far above the level of the body by using a large pillow is very injurious. This is a frequent cause of round shoulders. It is also important to lie

*Sleeping on a large pillow is very injurious*

outstretched at full length, so that the spine is straight. We have learned (page 100) how curvature of the spine may be caused by wrong postures in sitting and standing. In the same way our position in lying down to sleep may also cause deformities of the spine. When we are young the bones are soft. They fashion themselves according to the strain we put upon them. Then as we grow older, they gradually harden and we cannot straighten them again, no matter how much we should like to.

Curvature of the spine is a great danger to the nervous system, for in the spine are the delicate tissues of the spinal cord. We have learned (page 102) that the spinal cord has control of our physical movements and sensations. An injury to the spine may mean that we may lose the power to move our legs, and so we could no longer play or run about happily in the free out-of-doors. How important it is, then, to guard the bones of our bodies by assuming correct positions at all times, in our sleep as well as in our waking hours.

**How much sleep do we need?** We need sleep according to our age and state of health. Children should have from nine to twelve hours of sleep. The younger we are the more sleep we require. Children also need more sleep than adults because they are growing. During sleep the building-up process works fast, repairing tissues used up in play, besides adding new tissues to make the little bodies grow tall and strong.

Persons in ill health also need much sleep. Sleep is nature's restorative, more effective than any medicine in bringing back health.

**Good habits of exercise.** We have been warned (p. 101) against violent play. Such play frequently causes lifelong deformities that sometimes lead to early death. Here we see the

value of the habit of temperance. Play is of great value in the healthful development of the body and its organs. But it must be temperate and well regulated. Play is most beneficial in the open. But it is well to spend some time in the gymnasium because of its appliances. One may exercise therein when the weather is unfit for outdoor play. Gymnastic exercises should be taken under the supervision of a trained instructor, so that they will be properly done and not overdone. We should be careful, too, in taking part in competitive games, that we do not tax our physical strength too far. The same thing is true of bicycle riding, running, and such sports. In fact, any form of exercise if carried to excess does more harm than good. One of the best health habits we can observe is to exercise, but to exercise in moderation.

### QUESTIONS TO HELP THE PUPIL

1. Who chiefly has the duty of keeping our bodies well? 2. Describe the best positions for the body, and show why they are best. 3. Why does the body need more food while it is growing than it does after growth ceases? 4. Name four kinds of food elements and tell just how each kind helps the body. 5. What is a "balanced ration"? 6. In what ways do we destroy the balance? with what results? 7. Which is better, to have many kinds of food at one meal, or many kinds a few at a time? why? 8. What care should be taken in chewing the food? 9. Is chewing gum a good habit?

why? 10. How should the mouth be cared for? 11. When and how should the teeth be cleaned? 12. What precautions should be taken against contact with unwholesome bacteria? 13. Explain how cheerfulness aids digestion. 14. What things hinder digestion? 15. What are the digestive ferments? 16. What is the work of the ferments? 17. In what organs are they found? 18. How long does it take for food to digest? 19. Why should meals be eaten regularly? 20. Name some good habits in eating. 21. What is the work of the liver and kidneys? 22. What name is applied to them? 23. How is their work often made harder? 24. Show how alcohol hinders the work of the liver and kidneys. 25. What happens if waste products are left in the body? 26. Tell what you can of the nervous system. 27. Name the special senses and give the health habits regarding each one. 28. State what effect alcohol has on the nerves. 29. What effect has tobacco on the nerves? 30. Tell what you can of the laws regarding the sale and use of alcohol and tobacco. 31. Name several good sleep habits. 32. How much sleep do children need? 33. Why do children need more sleep than adults? 34. What is the value of exercise? 35. What habits should we observe with regard to play? gymnastic exercises? competitive games? running games? bicycle riding?

## XII. The Value of Health

**What is the value of health?** Children as a rule do not realize the money value of health. They realize its advantages, its freedom from pain, and the opportunity it gives them for enjoying life. But they do not realize that good health is also to be measured in dollars and cents. The mental efficiency of the child and of the grown person depends more largely on good health than on any other factor. Progress in school and in college depends to a great extent on the health of the individual. Success in the office or in the shop depends very largely on good health. The value of a citizen to the community and to his own family and friends is greater or less according to his state of health. It is therefore a matter of supreme importance for every one to know from his earliest years the fundamental facts of nutrition, of exercise, and of play, in order to secure a maximum of good health in childhood as well as in adult life.

**How is sickness costly?** Just as we may regard good health as an increase in money value and usefulness, so may we measure ill health as a loss in money value and usefulness. The sick person is not only unable to do useful work or

earn money, but he is also a burden to his family. The cost of professional medical service is often very great. Sickness is therefore a heavy burden on humanity, and we should do everything in our power to avoid it or to get rid of it if we are so unfortunate as to have it.

To be sick is to be useless. From whatever point of view we look at the matter, it pays to keep well, and it costs a lot of money to be sick.

**The object of study.** The object which the child has in view, or at least which the parents have in view during schooldays, is that he or she shall become a useful man or woman. Every factor in the training and conduct of the child which leads to this result is to be favored and promoted. Every obstacle which lies in the way of the achievement of this result is to be removed if possible.

Child life, from the physical point of view, has too long been neglected. To be healthy, well developed, and vigorous is not only the privilege but also the duty of every child. The harmonious development of all the organs of the body in the healthy child promotes the best development of the intellect and of the moral nature.

The purpose of writing this *Health Series* has been to lead the child little by little into a knowledge of those things which concern his

physical welfare and a realization that this is intimately related to his mental and moral welfare. The child who has read and carefully studied the principles laid down in these books is better prepared to attain health, happiness, and success in life than he otherwise would have been.

### QUESTIONS TO HELP THE PUPIL

1. Can good health be measured in dollars and cents as well as increased enjoyment of life? 2. Does mental efficiency depend on good health? 3. Does success in work depend on good health? 4. Is it a matter of supreme importance for every person to know the fundamental facts of nutrition, exercise, and play? 5. How can ill health be measured? What has been the purpose of the *Health Series* studies? 7. What advantage has the child who has carefully read and studied these health principles?

# THE VOCABULARY

[The diacritical marks used to indicate pronunciation agree with the latest edition of Webster's New International Dictionary.]

**abdomen** (ăb dō′mĕn)
the part of the body between the thorax and the pelvis
**abdominal** (ăb dŏm′ĭ năl)
pertaining to the abdomen
**abomasum** (ăb′ō ma′sŭm)
the fourth stomach of a ruminant
**albumin** (ăl bū′mĭn)
**alkaline** (ăl′kȧ līn; ăl′kȧ lĭn)
**amino** (ăm′ĭ nō; ȧ mē′nō)
**amylase** (ăm′ĭ lās)
a constituent of one of the digestive ferments which changes starch into sugar
**anaemia** (ȧ nē′mĭ ȧ)
**aorta** (ā ôr′tȧ)
the artery which carries the blood from the heart to all parts of the body except the lungs
**aqueous** (ā′kwē ŭs)
**astigmatism** (ȧ stĭg′mȧ tĭz′m)
**auditory** (ô′dĭ tō rĭ)

**biceps** (bī′sĕps)
**bolus** (bō′lŭs)

**caecum** (sē′kŭm)
**canine** (kȧ nīn′; kā′nīn)
like that of a dog
**capillaries** (kăp′ĭ lā rĭz)
minute, thin-walled vessels; the smallest blood vessels, which form the connection between the arteries and the veins
**carbohydrate** (kär′bō hī′drāt)
**carbon dioxide** (kär′bŏn dī ŏk′sīd)
**cardia** (kär′dĭ ȧ)
the opening of the esophagus into the stomach
**cardiac** (kär′dĭ ăk)
**carpal** (kär′păl)
pertaining to the wrist
**cartilage** (kär′tĭ lăj)
**cartilaginous** (kär′tĭ lăj′ĭ nŭs)
**casein** (kā′sē ĭn)
the name given to the form of protein found in milk
**cassava** (kă sä′vȧ)
**catalepsy** (kăt′ȧ lĕp′sĭ)
**cathartic** (kȧ thär′tĭc)
a medicine given to cleanse the bowels
**cellulose** (sĕl′ū lōs)
the substance forming the chief part of the solid framework of plants, of ordinary wood, linen, paper, etc.
**cerebellum** (sĕr′ē bĕl′ŭm)
**cerebral** (sĕr′ē brăl)
pertaining to the cerebrum
**cerebrum** (sĕr′ē brŭm)
**cervical** (sûr′vĭ kăl)
pertaining to the neck
**chyle** (kīl)
**chyme** (kīm)
**ciliary** (sĭl′ĭ ȧ rĭ)
hairlike
**clavicle** (klăv′ĭ k'l)
**clinic** (klĭn′ĭk)
an institution devoted to the examination and free treatment of patients, the work usually being done before students
**coagulating** (kō ăg′ū lāt′ĭng)
congealing, solidifying
**cocaine** (kō′kȧ īn; kō′kȧ ēn)
**coccygeal** (kŏk sij′ē ăl)
pertaining to the coccyx, the end of the spinal column
**codeine** (kō dē′ĭn; kō′dē ēn)
**colon** (kō′lŏn)

**coma** (kō′mȧ)
a state of bodily and mental inactivity from which it is difficult to arouse a person
**convolution** (kŏn′vō lū′shŭn)
**cornea** (kôr′nē ȧ)
**corpuscle** (kôr′pŭs′l)
**cystic** (sĭs′tĭk) **duct**
a duct from the gall bladder uniting with the hepatic duct to form the common bile duct

**dentine** (dĕn′tĭn)
**dextrin** (dĕks′trĭn)
**dextrose** (dĕks′trōs)
**diabetes** (dī ȧ bē′tēz)
**diaphragm** (dī′ȧ frăm)
**diastase** (dī′ȧ stās)
one of the digestive ferments, which converts starch into sugar
**dorsal** (dôr′sȧl)
**duodenum** (dū′ō dē′nŭm)

**enzymes** (ĕn′zīmz)
substances in the digestive organs which produce digestion by changing food from one form to another so that it may be absorbed
**esophagus** (ē sŏf′ȧ gŭs)
**ethmoid** (ĕth′moid)
one of the bones of the nasal cavity
**Eustachian** (ū stā′kĭ ăn)
**excretory** (ĕks′krē tō rĭ; ĕks krē′-tō rĭ)
serving for the elimination of waste and useless matter from the body

**feces** (fē′sēz)
**femur** (fē′mŭr)
**fibrin** (fī′brĭn)
**fibula** (fĭb′ū lȧ)
**filament** (fĭl′ȧ mĕnt)
a separate, threadlike fiber
**fovea centralis** (fō′vē ȧ sĕn trā′-lĭs)
a depression in the middle back part of the eyeball

**germicide** (jûr′mĭ sīd)
**gluten** (glōō′tĕn)
the substance which causes the sticky, adhesive quality in dough
**glycerin** (glĭs′ē rĭn)
**glycogen** (glī′kō jĕn)
**gustatory** (gŭs′tȧ tō rĭ)
pertaining to the sense of taste
**gypsum** (jĭp′sŭm)

**hepatic** (hē păt′ĭk) **duct**
the duct conveying the bile away from the liver
**heroin** (hē rō′ĭn; hĕr′ō ĭn)
**hordein** (hôr′dē ĭn)
the name given to the form of protein found in barley
**humerus** (hū′mēr ŭs)
**hydrochloric** (hī′drō klō′rĭk)
**hydrolysis** (hī drŏl′ĭ sĭs)

**ileo-caecal** (ĭl′ē ō sē′kȧl) **valve**
the valve at the opening of the ileum into the large intestine
**ileum** (ĭl ē ŭm)
**incisor** (ĭn sī′zēr; ĭn sī′sēr)
**incus** (ĭŋ′kŭs)
the middle of the three small bones in the ear
**indol** (ĭn′dōl; ĭn′dŏl)
**infantile** (ĭn′făn tīl; ĭn′făn tĭl)
pertaining to infancy or very young children
**iodine** (ī′ō dĭn; ī′ō dīn)

**jejunum** (jē jōō′nŭm)

**lachrymal** (lăk′rĭ mȧl)
a bone of the skull near the inner side of the eye
**lacteal** (lăk′tē ȧl)
**levulose** (lĕv′ū lōs)
**ligament** (lĭg′ȧ mĕnt)
**lipase** (lĭp′ās)
the enzyme which decomposes fat
**lumbar** (lŭm′bȧr)
near the loins
**lymphatic** (lĭm făt′ĭk)

**magnesia** (măg nē'zhĭ *ȧ*, zh*ȧ*; măg nē'shĭ *ȧ*, sh*ȧ*)
**malar** (mā'l*ȧr*)
the cheek bone
**malleus** (măl'ē *ŭs*)
the outermost of the three bones of the ear
**maltose** (môl'tōs; mŏl'tōs)
**mastoid** (măs'toid)
**medulla oblongata** (mē dŭl'*ȧ* ŏb'-lŏŋ gā't*ȧ*)
**mesenteric** (mĕs'ĕn tĕr'ĭk)
**artery:** one of the two arteries which pass between the two layers of membrane in the intestines
**vein:** a branch of the portal vein leading from the intestines
**metacarpal** (mĕt'*ȧ* kär'p*ăl*)
**metatarsal** (mĕt'*ȧ* tär's*ăl*)
**molar** (mō'l*ȧr*)
**morphine** (môr'fĭn; môr'fēn)
**mucous** (mū'k*ŭs*)
**mucus** (mū'k*ŭs*)

**narcotic** (när kŏt'ĭk)
**nasal** (nā'z*ăl*)
pertaining to the nose
**nausea** (nô'shē *ȧ*; nô'sē *ȧ*)
sickness of the stomach with a desire to vomit
**nitrate** (nī'trāt)
**nitrogen** (nī'trŏ jĕn)
**nitrogenous** (nī trŏj'ē n*ŭs*)
pertaining to or containing nitrogen

**occipital** (ŏk sĭp'ĭ t*ăl*)
the bone which forms the back part of the skull
**olfactory** (ŏl făk'tō rĭ)
**omasum** (ō mā's*ŭm*)
the third stomach of a ruminant
**orifice** (ŏr'ĭ fĭs)
**oxygen** (ŏk'sĭ jĕn)
one of the important elements of the air, forming about one fifth of it

**pancreas** (păŋ krē ăs)
**papillae** (p*ȧ* pĭl'ē)
**paralysis** (p*ȧ* răl'ĭ sĭs)
the loss of the power of voluntary motion in any part of the body
**parietal** (p*ȧ* rī'ē t*ăl*)
the bones forming the roof of the skull
**parotid** (p*ȧ* rŏt'ĭd)
**patella** (p*ȧ* tĕl'*ȧ*)
**pelvis** (pĕl'vĭs)
**peptone** (pĕp'tōn)
**periosteum** (pĕr'ĭ ŏs'tē *ŭ*m)
**peritoneum** (pĕr'ĭ tō nē'*ŭ*m)
the membrane lining the cavity of the abdomen
**peritosans** (pĕr ĭ tō's*ăn*z)
**phalanges** (f*ȧ* lăn'jēz)
the bones of the fingers and toes
**pharynx** (făr'ĭŋks)
**phenol** (fē'nōl; fē'nŏl)
**phosphate** (fŏs'fāt)
**phosphoric** (fŏs fŏr'ĭk)
**plasma** (plăz'm*ȧ*)
the watery part of the blood
**pons** (pŏnz)
**potash** (pŏt'ăsh)
**protein** (prō'tē ĭn)
**ptyalin** (tī'*ȧ* lĭn; p'tī'*ȧ* lĭn)
the diastase found in the saliva
**pylorus** (pĭ lō'r*ŭs*; pī lō'r*ŭs*)

**quadrate** (kwŏd'rāt)
nearly square in shape

**radius** (rā'dĭ *ŭs*)
**renal** (rē'n*ăl*)
pertaining to the kidneys
**rennin** (rĕn'ĭn)
**reticulum** (rē tĭc'*ŭ* lŭm)
the second stomach of a ruminant
**retina** (rĕt'ĭ n*ȧ*)
**rumen** (rōō'mĕn)
the first stomach of a ruminant
**ruminant** (rōō'mĭ n*ăn*t)

**sacral** (sā'krăl)
in the region of the sacrum, that part of the vertebral column connected with the pelvis
**saliva** (sȧ lī'vȧ)
the fluid secreted by the glands discharging into the mouth
**salivary** (săl'ĭ vȧ rĭ)
pertaining to the saliva; the salivary glands secrete saliva
**sartorius** (sär tō'rĭ ŭs)
**scapula** (skăp'ū lȧ)
**sclerotic** (sklē rŏt'ĭk)
**sensory** (sĕn'sō rĭ)
**sesamoid** (sĕs'ȧ moid)
**sigmoid flexure** (sĭg'moid flĕk' shûr)
the crooked portion of the intestine between the descending colon and the rectum; so called because of the double or S curve
**skatole** (skăt'ōl; skăt'ŏl)
**sphenoid** (sfē'noid)
the bone at one side of the base of that part of the skull which incloses the brain; so called because of its wedge shape
**Spigelian** (spī jē'lĭ ăn) **lobe**
named for Spigelia, a Dutch anatomist
**stapes** (stā'pēz)
the innermost bone of the ear; so called because of its stirrup shape
**steapsin** (stē ăp'sĭn)
**sternum** (stûr'nŭm)
**sublingual** (sŭb lĭŋ'gwăl)
**submaxillary** (sŭb măk'sĭ lȧ rĭ)
**submucosa** (sŭb'mū kō'sȧ)
the layer of tissue directly under a mucous membrane
**succulent** (sŭk'ū lĕnt)
full of juice; watery

**tarsal** (tär'săl)
**temporal** (tĕm'pō răl)
near the temples
**thoracic** (thō răs'ĭk)
pertaining to the thorax
**tibia** (tĭb'ĭ ȧ)
**trachea** (trā'kē ȧ; trȧ kē'ȧ)
**triceps** (trī'sĕps)
**trypsin** (trĭp'sĭn)
an enzyme which decomposes proteins
**tympanum** (tĭm'pȧ nŭm)

**ulna** (ŭl'nȧ)
**urea** (ū'rē ȧ)
**ureter** (ū rē'tĕr)
**urethra** (ū rē'thrȧ)

**vena cava** (vē'nȧ kā'vȧ)
one of the large veins by which the blood is returned to the right auricle of the heart
**venous** (vē'nŭs)
the term applied to the blood which is passing through the veins as opposed to *arterial* blood
**vertebra** (vûr'tē brȧ; pl. brē)
**villi** (vĭl'ĭ)
**viscid** (vĭs'ĭd)
**vitamine** (vī'tȧ mĭn)
**vitreous humor** (vĭt'rē ŭs hū'mĕr or ū'mĕr)

**zein** (zē'ĭn)
the name given to the form of protein found in Indian corn

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